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TITLE: HANFORD SITE GROUNDWATER MONITORING FOR FISCAL YEAR 2008

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# Hanford Site Groundwater Monitoring for Fiscal Year 2008

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# Abstract

This report presents the results of groundwater monitoring for fiscal year 2008 on the U.S. Department of Energy's Hanford Site in southeastern Washington. Results of groundwater remediation and vadose zone studies are summarized.

Contaminant plumes occupy an area of ~183 $km^2$ at levels exceeding one or more drinking water standards, compared to the total area (1,500 $km^2$) of the Hanford Site. The most extensive contaminant plumes in groundwater are tritium, iodine-129, and nitrate. These contaminants originated from multiple sources and are mobile in groundwater. The largest portions of these plumes are migrating from the central Hanford Site to the southeast, toward the Columbia River, and concentrations generally are declining. Carbon tetrachloride and associated organic constituents form a large plume beneath the west-central part of the Site. Hexavalent chromium is present in plumes beneath the reactor areas along the river and beneath the central part of the Site. Strontium-90 concentrations exceed drinking water standards beneath portions of all but one of the reactor areas. Technetium-99 and uranium plumes exceeding standards are present in the 200 Area. A uranium plume exceeding standards also underlies part of the 300 Area. Small contaminant plumes with concentrations greater than standards include carbon-14, cesium-137, cis-1,2-dichloroethene, cyanide, fluoride, plutonium, and trichloroethene.

Levels of some contaminants exceed drinking water standards in water samples collected from aquifer sampling tubes along the river shore. The most significant exceedances were strontium-90 in the 100-N Area, chromium in the 100-D Area, and uranium in the 300 Area.

Highlights for fiscal year 2008 include the following:

- Expansion of pump-and-treat systems in the 100-K Area to clean up chromium contamination
- Installation of an innovative, in-ground barrier at the 100-N Area to immobilize strontium-90 before it reaches the Columbia River
- Approval of a final record of decision for carbon tetrachloride remediation in the 200-ZP-1 Operable Unit.

Monitoring for the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* is conducted in 12 groundwater interest areas. The purpose of this monitoring is to define and track plumes and to monitor the effectiveness of remedial actions. One groundwater operable unit in the southern part of the Hanford Site (1100-EM-1 Operable Unit) was removed from the National Priorities List (40 CFR 300, Appendix B) because final remediation goals were reached. In fiscal year 2008, a final record of decision was approved for remediation of the 200-ZP-1 Operable Unit in the 200 West Area. This operable unit has been the subject of an interim remedial action for carbon tetrachloride. Interim groundwater remediation in the 100-K, 100-D, and 100-H Areas, using a combination of pump-and-treat and in situ methods, continued to reduce the amount of chromium reaching the Columbia River. An in situ treatment system for strontium-90 is being implemented in the 100-N Area. A pump-and-treat system for technetium-99 and uranium in the southern part of the 200 West Area also operated in fiscal year 2008.

This report meets annual reporting requirements for *Resource Conservation and Recovery Act of 1976* groundwater monitoring at 24 waste management areas:

- 15 under interim or final status detection programs, with the objective of determining whether or not they are adversely affecting groundwater (Monitoring results for Low-Level Waste Management Area 4 and the Nonradioactive Dangerous Waste Landfill exceeded a critical mean value. These two sites will be monitored under assessment programs in fiscal year 2009.)
- 7 under interim status groundwater quality assessment programs to assess contamination
- 2 under final status corrective-action programs.

During calendar year 2008, drillers completed 113 new wells for monitoring, remediation, or characterization, including six for *Resource Conservation and Recovery Act of 1976* requirements. One hundred three wells that could no longer be used were decommissioned (filled with grout).

This report is available on the Internet through the Hanford Site Groundwater Remediation Project (http://www.hanford.gov/cp/gpp).

# Acknowledgements

This report represents the efforts of dozens of people who contribute to the Soil and Groundwater Remediation Project: planners, schedulers, samplers, laboratory technicians, data management staff, scientists, editors, GIS professionals, and production staff. Stuart Luttrell, as manager of the monitoring and reporting task, provided valuable assistance in getting support from other organizations when we needed it.

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Thanks also to the many reviewers whose comments and suggestions helped us improve this report.

Mary Hartman

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# Report Contributors

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# Terms

| | |
|---|---|
| AEA | *Atomic Energy Act of 1954* |
| bgs | below ground surface |
| CERCLA | *Comprehensive Environmental Response, Compensation and Liability Act of 1980* |
| DOE | U. S. Department of Energy |
| DWS | drinking water standard |
| Ecology | Washington State Department of Ecology |
| EM-22 | Environmental Management Technology |
| EPA | U. S. Environmental Protection Agency |
| ERDF | Environmental Restoration Disposal Facility |
| FY | fiscal year |
| HEIS | Hanford Environmental Information System |
| HWIS | Hanford Well Information System |
| LIGO | Laser Interferometer Gravitational Wave Observatory |
| LLBG | low-level burial ground |
| Permit | WA7890008967, *Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion, Revision 8, for the Treatment, Storage, and Disposal of Dangerous Waste* |
| PUREX | Plutonium-Uranium Extraction (Plant or process) |
| QA | quality assurance |
| QC | quality control |
| RCRA | *Resource Conservation and Recovery Act of 1976* |
| REDOX | Reduction Oxidation (Plant) |
| SALDS | State-Approved Land Disposal Site |
| TEDF | Treated Effluent Disposal Facility |
| Tri-Parties | DOE, EPA, and Ecology |
| Tri-Party Agreement | Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order* |
| WIDS | Waste Information Data System |
| WMA | waste management area |

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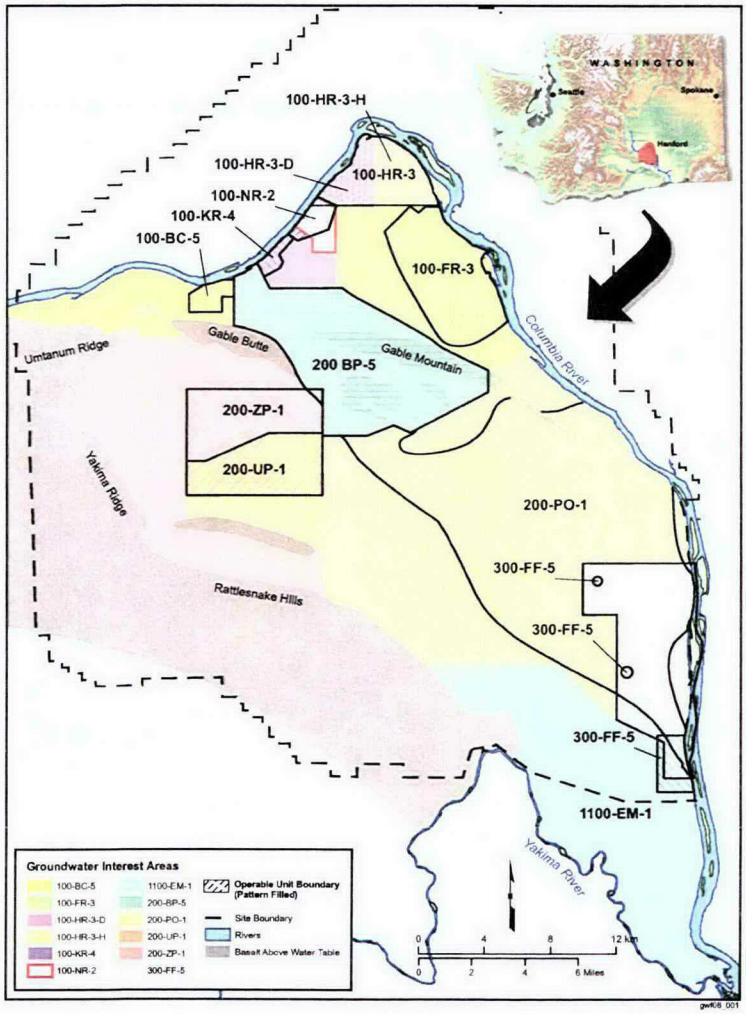
# Summary

## Introduction

The Hanford Site, part of the U.S. Department of Energy's (DOE) nuclear weapons complex, encompasses ~1,500 km$^2$ in southeastern Washington State. The Columbia River flows through the Site. The federal government acquired the Site in 1943, and until the 1980s used it to produce plutonium for national defense. Management of waste associated with plutonium production has been a major activity throughout the Site's history and continues today at a much reduced scale. Beginning in the 1990s, the DOE has focused on cleaning up the site.

The DOE is committed to protecting the Columbia River, human health, and the environment from the Site's contaminated groundwater. As part of this commitment, the DOE's groundwater management plan lays out steps for addressing groundwater and vadose zone contamination.

***The Hanford Site Groundwater Strategy focuses on three key areas: groundwater protection, groundwater monitoring, and remediation of contaminated groundwater.***



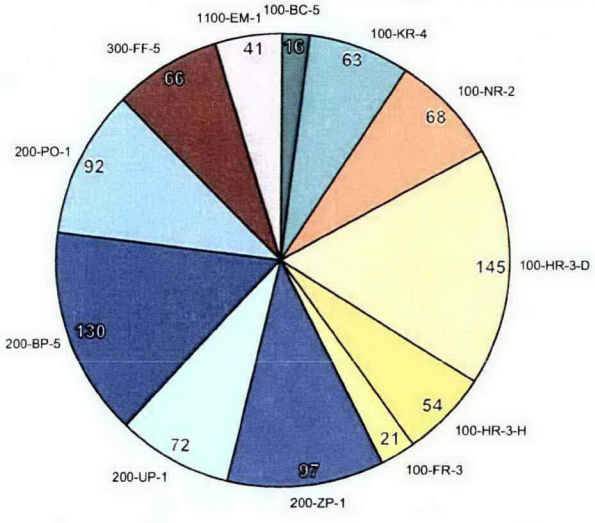

***Hanford Site groundwater monitoring is organized by areas of interest, which are informally named after the groundwater operable units. The areas of interest are useful for planning and scheduling groundwater monitoring and interpreting data.***

The DOE monitors groundwater at the Hanford Site to fulfill a variety of state and federal regulations, including the *Atomic Energy Act of 1954* (AEA), the *Resource Conservation and Recovery Act of 1976* (RCRA), the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), and *Washington Administrative Code*.

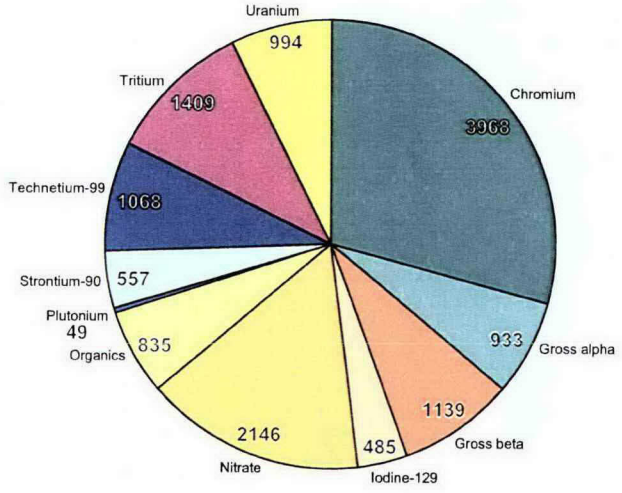
DOE Order 450.1, "Environmental Protection Program," implements requirements of the AEA. This Order requires environmental monitoring to detect, characterize, and respond to releases from the DOE activities, assess impacts, and characterize exposure pathways. The Order recommends implementing a site-wide approach for groundwater protection. The Order requires compliance with other applicable environmental protection requirements.

The Hanford Site has been divided into operable units, or groupings of similar waste units within a geographic area, so that the CERCLA process can be efficiently implemented. Most operable units are source operable units, but eleven are groundwater operable units. The concept of the groundwater operable unit was adopted to allow separate characterization of the waste sites and the groundwater. Separate characterization recognizes differences between localized contaminants in the soil column at the sources and the more widespread, mingled contamination in groundwater. Monitoring wells are located and sampled to define the nature and extent of the contaminant plumes. Groundwater also is monitored to assess the effectiveness of groundwater remediation.

The groundwater monitoring requirements for the Site's RCRA units fall into one of two categories: interim status or final status. A permitted RCRA unit requires final status monitoring, as specified in WAC 173-303-645, "Dangerous Waste Regulations; Releases from Regulated Units." RCRA units not currently incorporated into permits require interim-status monitoring, as specified in WAC 173-303-400, "Dangerous Waste Regulations; Interim Status Facility Standards" (based on 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities").




***This chart shows the number of wells sampled in each groundwater interest area in FY 2008.***




***The groundwater project requests specific laboratory analyses based on the wells' locations, historical contaminant trends, and regulatory requirements. This graph shows the number of analyses for the most common constituents during FY 2008.***

RCRA groundwater monitoring is conducted under one of three possible phases.

**Indicator Parameter** (or final status detection). Initially, a detection program uses groundwater data to determine and monitor the impact, if any, of the facility on groundwater. Monitoring results for Low-Level Waste Management Area 4 and the Nonradioactive Dangerous Waste Landfill exceeded a critical mean value. These two sites will be monitored under assessment programs in FY 2009.

**Assessment** (or final status compliance). If the detection monitoring results indicate a statistically significant change in chemistry, then an assessment or compliance phase of monitoring begins.

**Corrective Action** (via administrative order for interim status sites or during final status). If the source of the contamination is determined to be the RCRA unit and the concentration exceeds applicable limits, then Washington State Department of Ecology (Ecology) may require corrective action. Groundwater is monitored to determine if the corrective action is effective.

***The DOE sampled 865 wells during FY 2008. Chromium, nitrate, and tritium are constituents most frequently analyzed.***

In fiscal year (FY) 2008, workers sampled 865 monitoring wells and 297 shoreline aquifer tubes to determine the distribution and movement of contaminants. Many of the wells and some of the aquifer tubes were sampled multiple times during the year.

A total of 3,968 samples of Hanford Site groundwater were analyzed for chromium, 2,146 for nitrate, and 1,409 for tritium. Other constituents frequently analyzed include gross beta (1,139), technetium-99 (1,068), uranium (994), gross alpha (933), and carbon tetrachloride (835). These totals include results for routinely sampled groundwater wells, pump-and-treat operational samples, and aquifer tube samples.

## Items of Interest

This section briefly describes some of the high-priority groundwater topics for FY 2008.

***The DOE is focusing remediation efforts on activities that protect the Columbia River.***

***River Corridor Baseline Risk Assessment.*** To support the decision-making process for final CERCLA remedial actions within the Columbia River Corridor, the DOE is conducting a CERCLA remedial investigation including a baseline risk assessment for the River Corridor portion of the Hanford Site. The risk assessment consists of three components: the 100 Area and 300 Area Component, the Inter-Area Component, and the Columbia River Component. The 100 Area and 300 Area Component and the Inter-Area Component will be integrated with groundwater into a series of final CERCLA remedial investigation reports for the operational areas of the River Corridor.

***Systematic Planning for the 100 Area.*** A systematic planning process uses a common sense, graded approach to ensure that the level of detail in planning is commensurate with the importance of the work being planned. The DOE, U.S. Environmental Protection Agency (EPA), Ecology, Tribal Nations, and stakeholders initiated the systematic planning process for the 100 Area in FY 2008. Using this process, the DOE is preparing a work plan for a remedial investigation and feasibility study to support selection of a final remedy under CERCLA for source and groundwater operable units in the 100 Area. The work plan will document how decisions are made and specify collection details for required data. It also

will describe the procedures for evaluating cleanup alternatives and identifying the preferred remedy.

***100-KR-4 Pump-and-Treat Expansion.*** The DOE installed new extraction and injection wells and constructed a new treatment system with a designed treatment capacity of 2,271 L/min. When it begins to operate in FY 2009, the expansion will allow the pump-and-treat for hexavalent chromium to capture more of the plume around the 116-K-2 Trench.

***100-N Apatite Barrier.*** Workers conducted a second round of injections of apatite-forming chemicals into a line of groundwater wells along the 100-N Area shoreline in FY 2008. Strontium-90 concentrations initially increased in many wells, but then declined as the remediation began to take effect. Tests are also being conducted to emplace apatite into the vadose zone by surface infiltration.

***100-HR-3 Characterization and Testing.*** The DOE continued characterization and research in the 100-D and 100-H Areas in FY 2008. The objectives were to characterize the chromium plume between 100-D and 100-H Areas; locate the source of the chromium plume in southern 100-D Area; characterize deep chromium contamination; test biostimulation, an in situ remediation method for chromium in the aquifer; test nanometer-size iron injection, a method to increase effectiveness of the redox barrier in 100-D Area; and test electrocoagulation, a water-treatment process.

***In FY 2008, the DOE, EPA, and Ecology signed a final record of decision for the 200-ZP-1 Operable Unit.***

***200-ZP-1 Record of Decision.*** In September 2008, the DOE, EPA, and Ecology (Tri-Parties) signed a final record of decision for groundwater remediation in the 200-ZP-1 Operable Unit. The selected remedy combines pump-and-treat, monitored natural attenuation, flow-path control, and institutional controls.

***300-FF-5 Studies.*** Scientists continued an aggressive campaign to investigate the uranium plume in the 300 Area in FY 2008. Recent work included updating computer simulations of groundwater flow and uranium transport; conducting a limited field investigation of uranium involving multiple characterization boreholes; updating to the human health and ecological risk assessment; and conducting an assessment of potential remedial action technologies for the 300 Area uranium plume.

***New Aquifer Tubes.*** The DOE installed 139 new aquifer tubes in 61 locations along the Columbia River shoreline from the 100-B/C Area to the 300 Area. The tube locations were chosen to fill gaps in the existing aquifer tube network. The section of the shoreline where the 200 Area tritium plume approaches the river now has 11 new monitoring locations. Early data from the new tubes confirm the known distribution of contaminants in groundwater near the river.

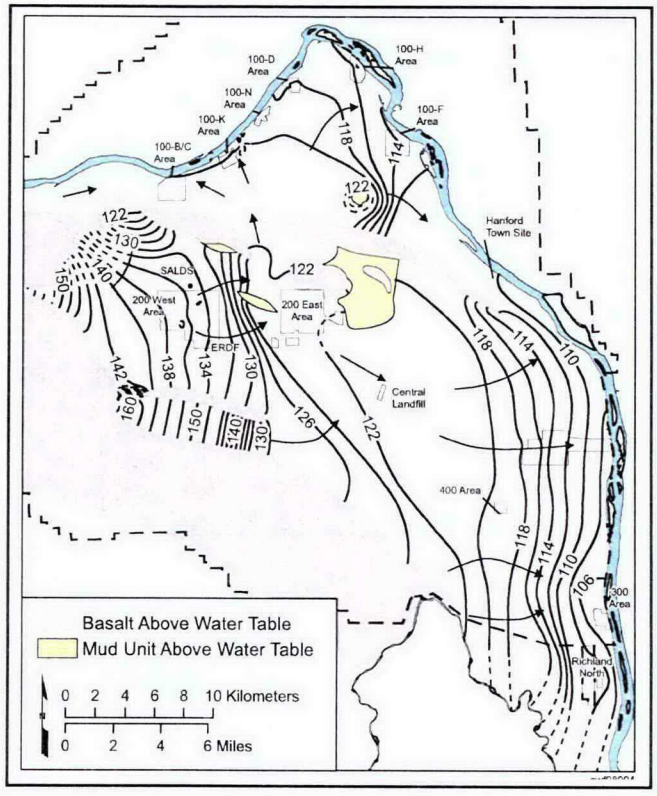
***Tri-Party Well Installation Agreement.*** The Tri-Parties approved an agreement in August 2008 that provides a three-year rolling, prioritized well drilling schedule through calendar year 2011. The Tri-Parties will hold discussions and update this milestone each year.

## Groundwater Flow

General directions of groundwater flow are illustrated on the water-table map for March 2008. The direction of groundwater flow is inferred from water-table elevations, barriers to flow (e.g., basalt or mud units at the water table), and the distribution of contaminants. Groundwater enters the unconfined aquifer from recharge areas to the west and eventually discharges to the Columbia River. Additional

water infiltrates through the vadose zone beneath the Hanford Site. Hydrologists estimate that the total discharge of groundwater from the Site aquifer to the Columbia River is in the range 1.1 to 2.5 $m^3$/sec. This rate of discharge is less than 0.075% of the average flow of the river (~3,400 $m^3$/sec).

The water table beneath the 200 East Area is relatively flat because of the presence of highly permeable sediment of the Hanford formation at the water table. Groundwater enters the vicinity of the 200 East Area from the west and southwest. The flow of water divides, with some flowing to the north through a gap between Gable Butte and Gable Mountain (Gable Gap) and some flowing southeast toward the central part of the Site. This groundwater divide may be located near the central part of the 200 East Area, but its precise location is unknown. Ongoing studies will help determine the direction of groundwater flow in this region. In the southern part of the Hanford Site, groundwater enters the 300 Area from the northwest, west, and southwest.




***This map shows the water table and inferred flow directions in March 2008.***

The natural pattern of groundwater flow was altered during the Hanford Site's operating years by water-table mounds. The mounds were created by the discharge of large volumes of wastewater to the ground and were present in each reactor area and beneath the 200 Area. Since effluent disposal decreased significantly in the 1990s, these mounds have dissipated in the reactor areas and have declined considerably in the 200 Area. Currently, wastewater is discharged to the ground at the State-Approved Land Disposal Site, north of the 200 West Area (67.8 million liters in 2008), and at the Treated Effluent Disposal Facility, east of the 200 East Area (2.76 million liters).

Groundwater flow in the unconfined aquifer is currently altered where extraction or injection wells are used for pump-and-treat systems. Extraction wells in the 100-K, 100-D, 100-H, and 200 West Areas capture contaminated water from the surrounding areas. Water flows away from injection wells, which are upgradient of the contaminant plumes, so the injection increases the hydraulic gradient toward the extraction wells.

A confined aquifer occurs within sand and gravel of the lowest sedimentary unit of the Ringold Formation. It is confined between basalt and the lower mud unit. The unconfined aquifer does not extend east of the 200 East Area due to the presence of Ringold Formation mud units at the water table (shaded tan on the water-table map), so the Ringold Formation confined aquifer is the uppermost aquifer in this area. Beneath the Ringold Formation confined aquifer is the upper basalt-confined aquifer, which exists mainly in the Rattlesnake Ridge interbed, the uppermost widespread sedimentary interbed between basalt flows. Groundwater within these confined aquifers is influenced by a residual recharge mound in the vicinity of the B Pond. Several wells north and east of the 200 East Area have shown evidence of intercommunication between the upper basalt-confined aquifer and the overlying aquifers. The intercommunication has been attributed to erosion of the upper Saddle

Mountains Basalt and a downward hydraulic gradient. Since an upward gradient exists elsewhere in the 200 East Area/Gable Gap region, the upper basalt-confined aquifer likely discharges to the overlying aquifers, especially within Gable Gap where the Elephant Mountain Basalt was removed by erosion.

## Groundwater Monitoring and Remediation

***The sampling and analysis of groundwater provides data to help characterize the nature, potential fate, and transport of contaminants in the environment.***

Some Hanford Site contaminants have moved downward from waste sites, through the vadose zone, into the groundwater, and then toward the Columbia River. Sampling groundwater helps determine how the contaminants move through the environment. The DOE works with regulatory agencies (e.g., the EPA and Ecology) to make cleanup decisions based on sound technical information.

The DOE has developed a plan with steps for cleaning up groundwater and the vadose zone. Key elements include the following.

- Continue to implement remedies that are working.
- Gather characterization data to help make informed decisions.
- Address emerging problems.
- Work with regulatory agencies to make remediation decisions.
- Identify new cleanup technologies.
- Continue to monitor groundwater to detect emerging problems and determine how well remedies are working.

Final groundwater cleanup remedies have been selected for two portions of the Hanford Site: the 200-ZP-1 and 1100-EM-1 Operable Units. Interim remedial actions are underway in other portions of the site: the 100-KR-4, 100-NR-2, 100-HR-3, 200-UP-1, and 300-FF-5 Operable Units. Records of decision for groundwater cleanup have not yet been established for the remaining portions of the site (the 100-BC-5, 100-FR-3, 200-BP-5, and 200-PO-1 Operable Units) because groundwater

**Major Groundwater Contaminants on the Hanford Site.**

| Contaminant | Primary Locations | Plume Area ($km^2$) | Drinking Water Standard | Remediation in Place? | Mobility and Half-Life |
|---|---|---|---|---|---|
| Carbon Tetrachloride | 200-ZP-1 | 11.2 | 5 µg/L | Yes | Mobile (denser than water) |
| Chromium | 100-KR-4, 100-HR-3 | 2.1 | 100 µg/L | Yes | Mobile (hexavalent) |
| Cyanide | 200-BP-5 | 0.3 | 200 µg/L | No | Mobile |
| Iodine-129 | 200-BP-5, 200-PO-1, 200-UP-1 | 65.5 | 1 pCi/L | No | Mobile; 15.7 million years |
| Nitrate (as $NO_3$) | 100-FR-3, 200 Area | 36.3 | 45 mg/L | No | Mobile |
| Strontium-90 | 100-NR-2, 200-BP-5 | 2.2 | 8 pCi/L | Yes, 100-NR-2 | Moderate; 28.8 years |
| Technetium-99 | 200-BP-5, 200-UP-1 | 2.4 | 900 pCi/L | Yes, 200-UP-1 | Mobile; 211,000 years |
| Trichloroethene | 100-FR-3, 200-ZP-1 | 0.7 | 5 µg/L | Yes, 200-ZP-1 | Mobile |
| Tritium | 200 Area, 300-FF-5 | 127 | 20,000 pCi/L | No | Mobile; 12.3 years |
| Uranium | 200-UP-1, 200-BP-5, 300-FF-5 | 1.5 | 30 µg/L | Yes, 200-UP-1 | Moderate; 246,000 years (U-234), 4.5 billion years (U-238) |
| Combined plumes | | 183 | | | |

| Groundwater Remediation. | | |
|---|---|---|
| **Remedial Action Site** | **Dates Active** | **Progress from Start to September 2008** |
| 100-K Area - 100-KR-4 Pump-and-Treat System | 1997-present | Decreases chromium to river; 330 kg removed. System being expanded. |
| 100-K Area - KW Pump-and-Treat System | 2007-present | Decreases chromium to river; 31 kg removed. System being expanded. |
| 100-N Area - 100-NR-2 Pump-and-Treat System | 1995-2006 | 1.8 Ci of strontium-90 removed |
| 100-N Area - Apatite Barrier | 2006-present | Test injections of low- and high-concentration solutions; apatite barrier beginning to form |
| 100-D Area - 100-HR-3 Pump-and-Treat System | 1997-present | Decreases chromium to river; 287 kg removed |
| 100-D Area – 100-DR-5 Pump-and-Treat System | 2004-present | Decreases chromium to river; 211 kg removed |
| 100-D Area - In Situ Redox | 1999-present | Decreases chromium concentrations downgradient of barrier. Showing breakthrough; amendments being tested. |
| 100-H Area - 100-HR-3 Pump-and-Treat System | 1997-present | Decreases chromium to river; 51 kg removed. |
| 200 West Area - 200-ZP-1 Pump-and-Treat System | 1994-present | Prevents high-concentration portion of carbon tetrachloride plume from spreading; 11,415 kg removed. System being expanded to implement final ROD. |
| 200 West Area - Soil-Vapor Extraction | 1992-present | Reduces carbon tetrachloride movement to groundwater; 79,400 kg removed from vadose zone. |
| 200 West Area - WMA T Pump-and-Treat System | 2007-present | Removes technetium-99 from the aquifer. 23.8 g (0.4 Ci) removed. |
| 200 West Area - 200-UP-1 Pump-and-Treat System | 1994-2005<br>2007-present | Decreases lateral migration of contaminants; 141.6 g technetium-99 (2.4 Ci) and 218.2 kg of uranium removed. |
| 200 West Area - WMA S-SX Pump-and-Treat System | 2003-present | Decreases technetium-99 concentrations; 0.38 g (0.0064 Ci) removed. |
| 300 Area - 300-FF-5 Natural Attenuation | ongoing | Trichloroethene concentrations in upper aquifer below target level; uranium concentrations above target level |
| 1100-EM-1 Natural Attenuation | complete | Trichloroethene concentrations below 5 µg/L since 2001 |

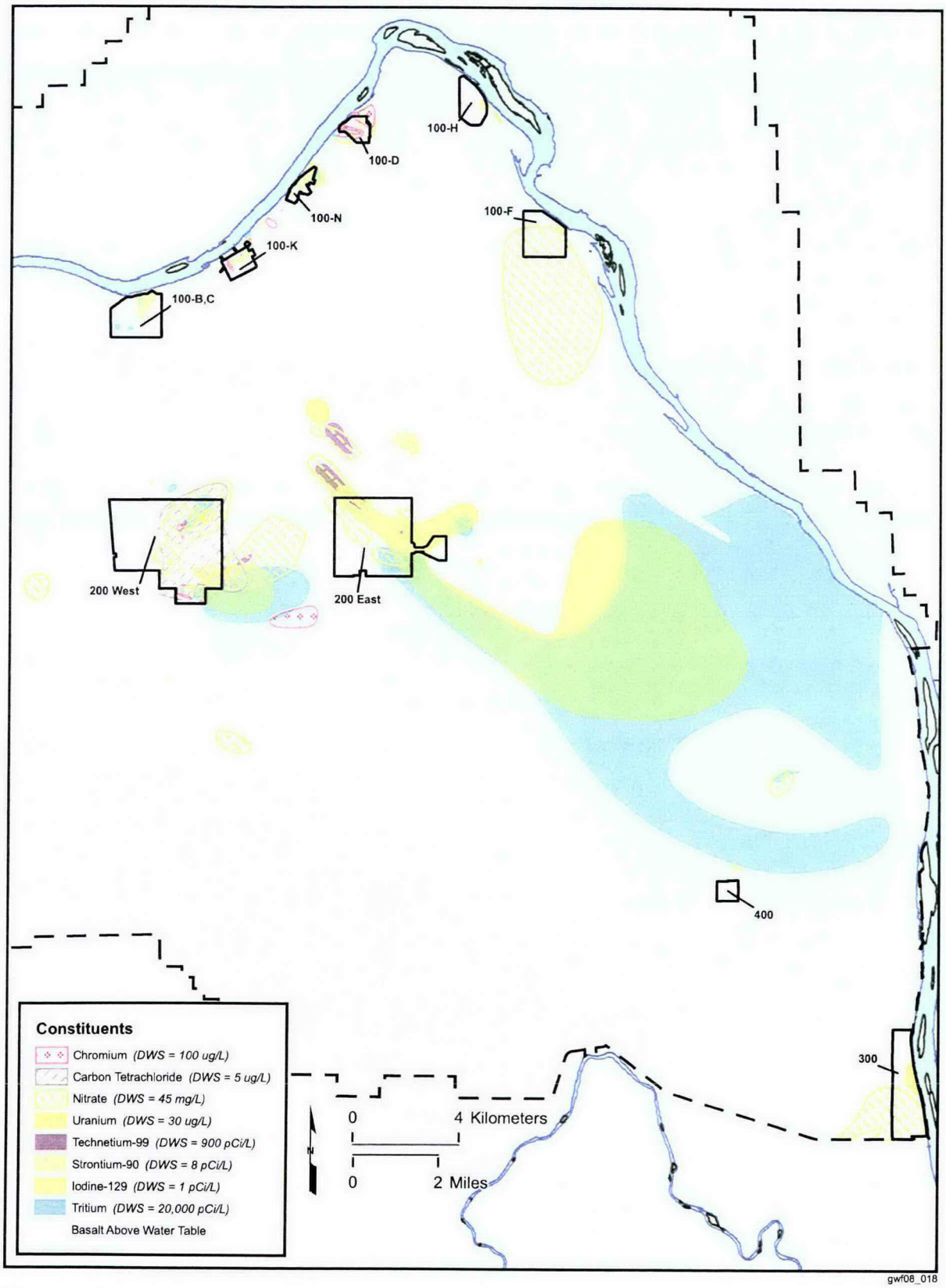
conditions do not warrant interim remedial measures. However, final remedies are being developed for all of the operable units.

## Sitewide Plumes

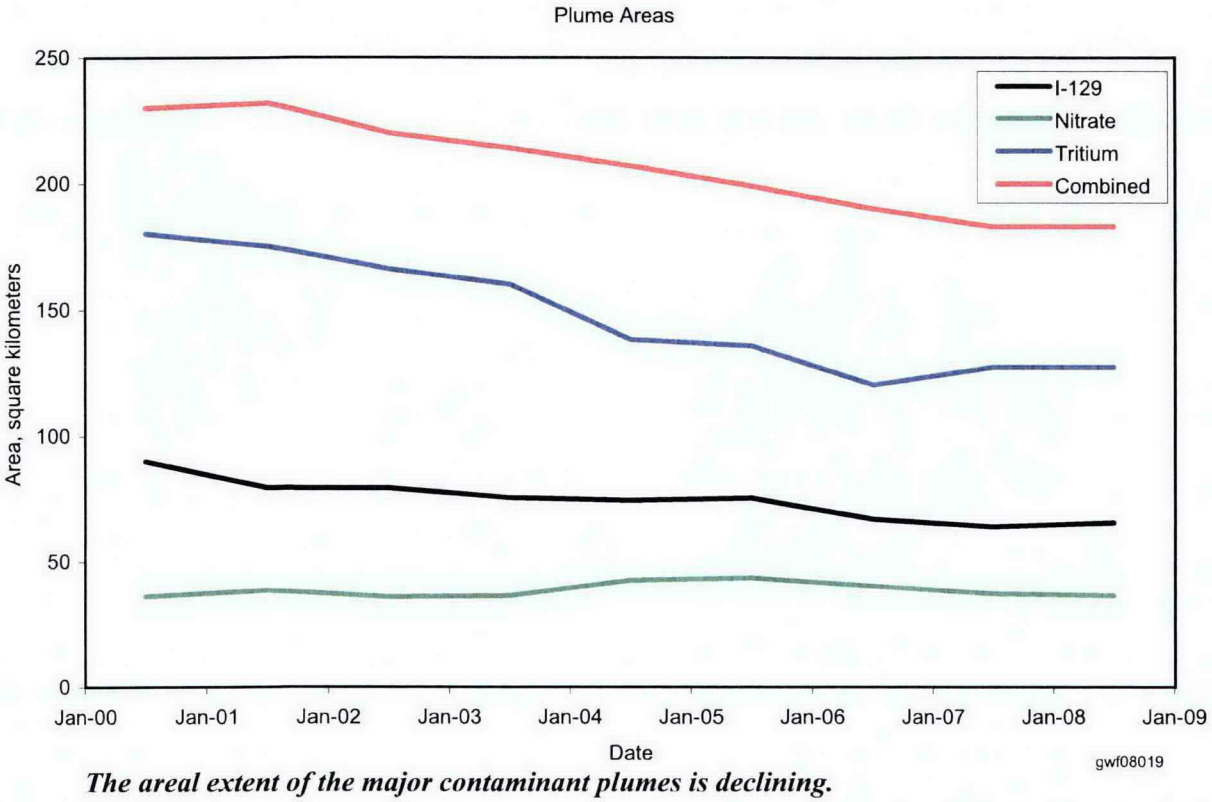
The map on page xviii shows the extent of eight groundwater contaminant plumes in the upper part of the unconfined aquifer. The footprint of the combine plumes occupies approximately 183 $km^2$, or about 12% of the total area of the Hanford Site. The area of the major plumes is declining gradually.

Of the radionuclide plumes, tritium and iodine-129 have the largest areas with concentrations above drinking water standards. The dominant plumes had sources in the 200 East Area and extend toward the east and southeast. Less extensive tritium and iodine-129 plumes also are present in 200 West Area. Technetium-99 exceeds its standard in the 200 East and 200 West Areas. One technetium-99 plume extends northward, beyond the 200 East Area. Uranium is less mobile than tritium, iodine-129, or technetium-99; plumes containing uranium are found in the 200 East, 200 West, and 300 Areas. Strontium-90 exceeds standards in the 100 Areas, 200 East Area, and beneath the former Gable Mountain Pond. Cesium-137, cobalt-60, and plutonium exceed drinking water standards in only a few wells in the 200 East Area.

Nitrate is a widespread chemical contaminant in Hanford Site groundwater; plumes originate from the 100 and 200 Areas and from offsite industry and agriculture. Carbon tetrachloride is the most widespread organic contaminant on the Hanford Site, forming a large plume beneath the 200 West Area. Other organic contaminants include chloroform (found in 200 West Area) and trichloroethene. The 100-F Area has a plume of trichloroethene and the 100-K Area has one well that exceeded the trichloroethene standard. Wells completed in a fine-grained layer beneath the 300 Area also detected trichloroethene at levels above the drinking water standard. Chromium at levels




***This map shows the distribution of the major contaminant plumes at concentrations above the drinking water standard during FY 2008 in the upper part of the unconfined aquifer.***




***The areal extent of the major contaminant plumes is declining.***

above the 100 µg/L drinking water standard underlies portions of the 100-K and 100-D Areas. Chromium exceeds Washington State's aquatic standard (10 µg/L) in these areas and portions of the 100-B/C, 100-H, 100-F, and 600 Areas. Local plumes of chromium contamination also are present in the 200 Areas.

The following text discusses groundwater contamination, monitoring, and remediation for each of the groundwater operable units or groundwater interest areas and in the confined aquifers.

## 100-BC-5 Operable Unit

Most of the groundwater contamination is found in the northern portion of the 100-B/C Area, beneath former waste trenches and retention basins. Tritium and strontium-90 concentrations exceeded drinking water standards in several wells. Nitrate and chromium concentrations continued to be below drinking water standards in recent years, but chromium levels exceed the 10 µg/L aquatic standard.

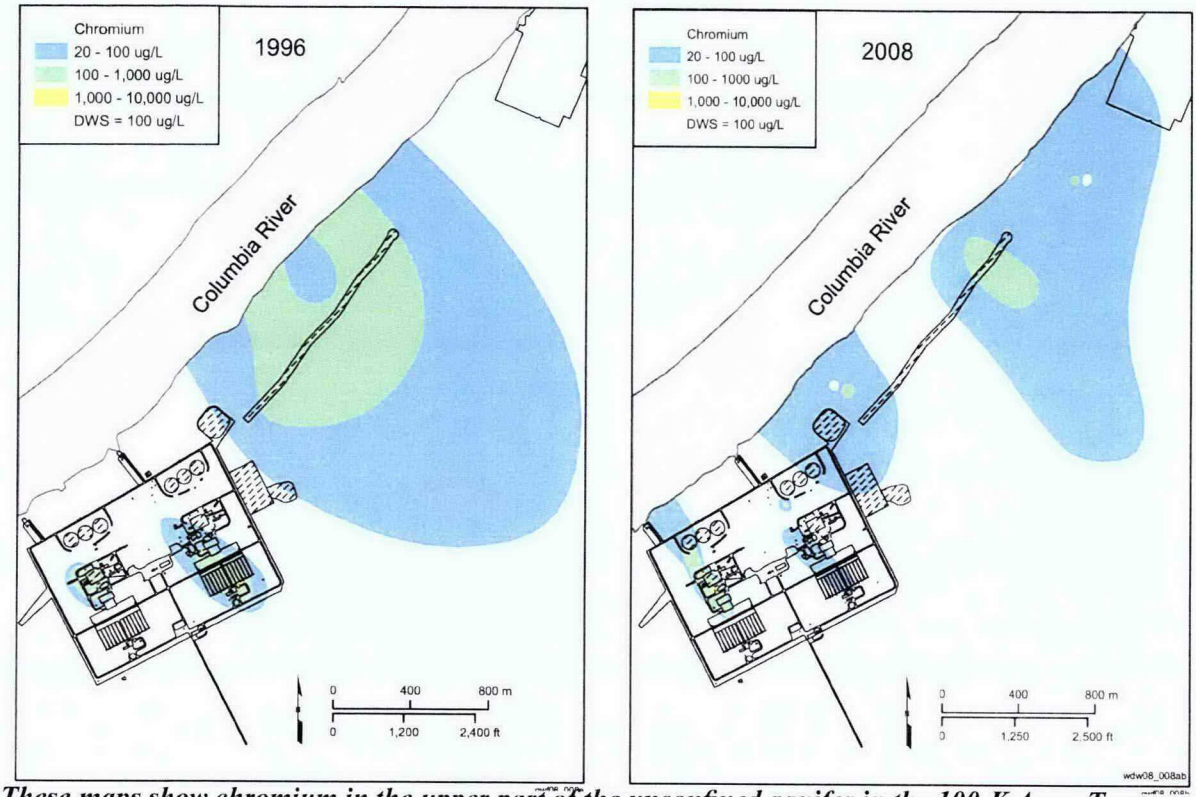
A record of decision has not yet been developed for the 100-BC-5 Operable Unit, and no active remediation of groundwater is underway. Groundwater monitoring has continued since the initial remedial investigation and while waste site remedial actions are being conducted.

## 100-KR-4 Operable Unit

The principal groundwater issues in this operable unit include cleaning up chromium in groundwater; tracking plumes from past-practices sites; and monitoring groundwater near the KE and KW Basins. Interim remedial action involves two pump-and-treat systems that remove chromium from groundwater.

***Interim Remedial Action.*** A pump-and-treat system is removing hexavalent chromium from the aquifer beneath the 116-K-2 Trench. Approximately 330 kg of chromium have been removed since startup in 1997. New wells installed in FY 2008

***New wells were installed to expand the 100-K Area Pump-and-Treat System near the 116-K-2 Trench. The new wells will start operating in FY 2009.***




***These maps show chromium in the upper part of the unconfined aquifer in the 100-K Area. Two pump-and-treat systems reduce the amount of chromium entering the Columbia River.***

showed that one portion of the plume with concentrations above 100 µg/L is larger than was previously known. Chromium concentrations in most of the compliance wells near the river have decreased. The concentration goal for the interim remedial action is 22 µg/L at compliance wells.[1] New extraction and injection wells were installed in FY 2008 and will begin to operate in FY 2009. The expanded system will increase the amount of contaminated groundwater being treated, and will prevent the plume from moving downgradient into the 100-N Area.

In 1998, chromium concentrations in groundwater near the KW Reactor began to rise. Concentrations in this plume are the highest in the 100-K Area. The DOE has operated a pump-and-treat system to clean up the plume since 2007. The system has removed 31 kg of chromium from the aquifer, and concentrations in the extraction wells have declined. Plans are underway to expand the KW system in FY 2009.

***Monitoring Past-Practice Waste Sites.*** Other contaminants of potential concern in the operable unit are carbon-14, nitrate, strontium-90, trichloroethene, and tritium. Levels remained above drinking water standards, and these contaminants will be addressed under an upcoming remedial investigation/feasibility study work plan and final record of decision.

Tritium concentrations in two new wells near the south end of the 116-K-2 Trench are much higher than in surrounding wells. The source for tritium at this location is uncertain; it may represent past disposal to the 116-KE-1 Crib or 116-K-2 Trench, or tritium from a source farther inland, such as the 118-K-1 Burial Ground.

1 Certain monitoring wells are designated compliance wells in the interim action records of decision. Chromium concentrations in samples from these wells are compared to the remediation goal to determine if the remedial action is effective.

***KE and KW Basins.*** These concrete basins are integral parts of each reactor building. From the late 1970s to 2004, they were used to store irradiated fuel from the last run of the 100-N Reactor, as well as miscellaneous fuel fragments recovered during remedial actions at other reactor areas. In FY 2008, monitoring of water levels in the basins and groundwater in downgradient wells indicated no new leaks. Shielding water has been removed from the KE Basin and demolition of the basin has begun, so the groundwater monitoring strategy will be reviewed.

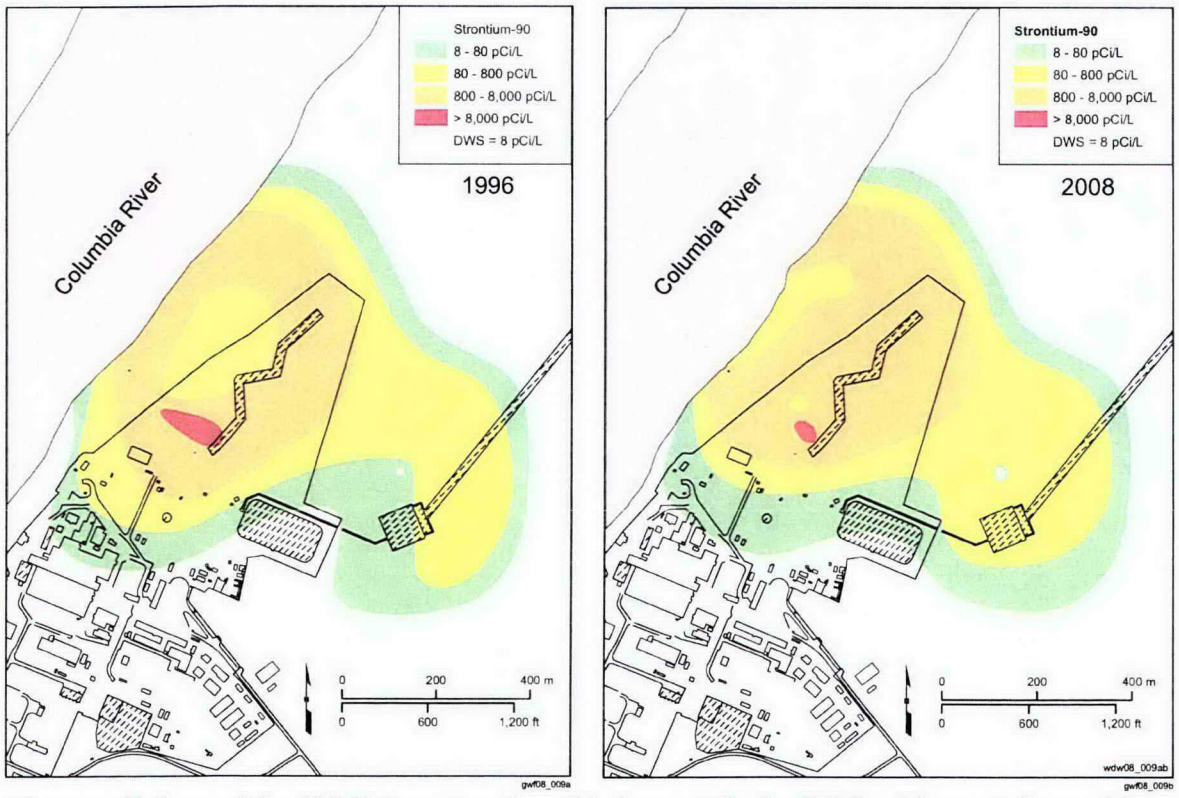
## 100-NR-2 Operable Unit

The primary groundwater contaminant plume in the 100-N Area is strontium-90, which originated at two liquid waste disposal facilities. Tritium, nitrate, sulfate, and petroleum hydrocarbons also are present in the groundwater.

***Interim Remedial Action.*** The DOE is applying an in situ technology, apatite sequestration, in the 100-N Area. The goal is to create a permeable, reactive barrier that will capture strontium-90 as groundwater flows through it to the Columbia River. Apatite-forming chemicals were injected into a line of wells along the river shore in FY 2007 and 2008. As the injected chemicals reacted with the aquifer, strontium-90 levels initially increased in downgradient wells and aquifer tubes. However, in the weeks and months after the injections, the chemical reactions progressed and strontium-90 levels declined. Concentrations in the barrier wells were much lower at the end of FY 2008 than they were before the injections.

***Strontium-90 concentrations temporarily increased in response to injections to the 100-N Area apatite barrier. Levels subsequently dropped and are expected to continue declining.***

Other forms of remediation being investigated at the 100-N Area include apatite infiltration and phytoremediation (plants) to treat contamination above the average water table and in shallow groundwater.




***The overall shape of the 100-N Area strontium-90 plume at the 8 pCi/L level has not changed in many years, despite the operation of the pump-and-treat system from 1995 until March 2006.***

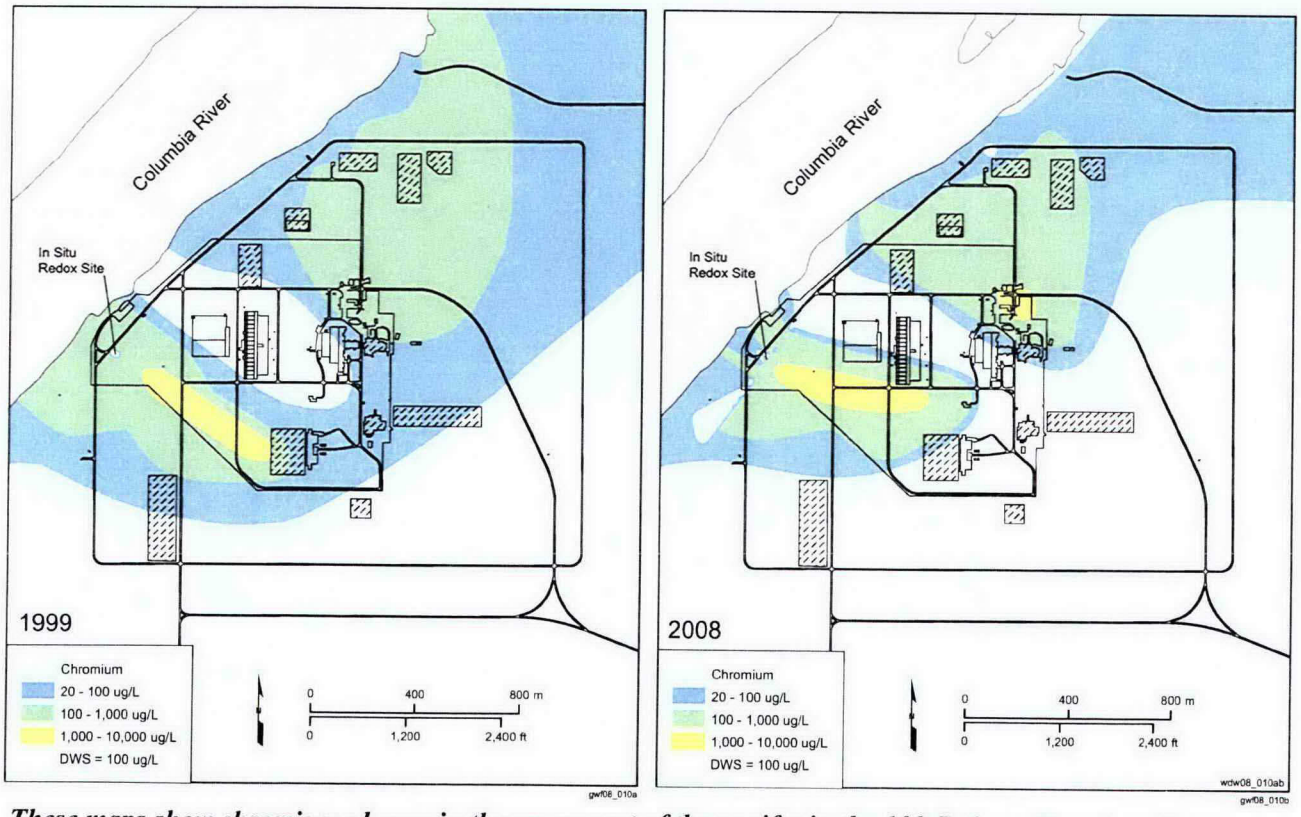
***116-N-1, 116-N-3, 120-N-1, and 120-N-2 Facilities.*** Four RCRA units are located in the 100-N Area. During FY 2008, the sites remained in detection monitoring programs. AEA and CERCLA monitoring continued to track strontium-90 and tritium plumes from the 116-N-1 and 116-N-3 Facilities and sulfate from the 120-N-1 Percolation Pond.

***Hexavalent chromium concentrations in 100-D Area groundwater are the highest on the Hanford Site.***

## 100-HR-3-D Groundwater Interest Area

The 100-HR-3 Operable Unit underlies the 100-D Area, 100-H Area, and the region between them. The western portion of this operable unit is the 100-HR-3 groundwater interest area. Hexavalent chromium is the principal contaminant of concern in groundwater beneath the operable unit. A principal cause for this contamination was the routine disposal of reactor coolant, which contained sodium dichromate as a corrosion inhibitor. Periodic spills and leaks of sodium dichromate stock solution to the ground were another source of contamination. Chromium is distributed in northern and southern plumes. Other contaminants include tritium, nitrate, strontium-90, and sulfate.

***Interim Remedial Actions.*** The northern chromium plume is the target of a pump-and-treat system, which is designed to reduce the amount of chromium entering the Columbia River. A second pump-and-treat system intercepts groundwater in the central 100-D Area near the shoreline. In FY 2008, chromium concentrations remained above the remediation goal (22 µg/L for the pump-and-treat systems) in compliance wells. The two extraction systems have removed 497 kg of chromium from the aquifer since 1997. The southern chromium plume is being remediated with a permeable barrier that immobilizes chromium in the aquifer. Data from recent years



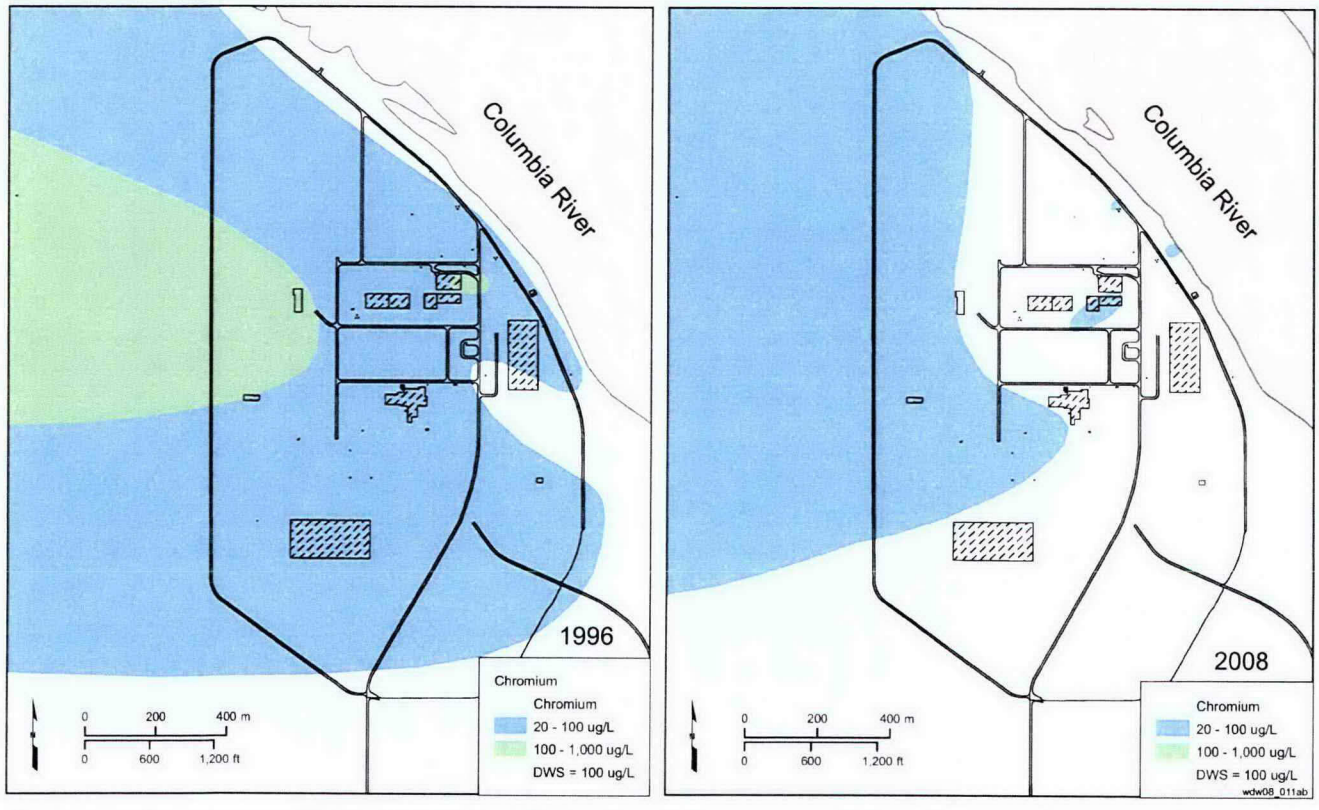

***These maps show chromium plumes in the upper part of the aquifer in the 100-D Area. To reduce the amount of chromium entering the Columbia River, the DOE operates two pump-and-treat systems in the north and an in situ treatment system in the south.***

indicate that, in some locations, chromium has migrated through the barrier. At the end of FY 2008, concentrations in barrier wells ranged from below detection limits to 780 µg/L. Most of the elevated concentrations are in the northeastern half of the barrier. The remediation goal (20 µg/L for the permeable barrier) was met at only two of the seven compliance wells. However, concentrations have declined overall in most of the compliance wells.

***Data from new wells help pinpoint the source of chromium in the 100-D Area vadose zone and characterize the chromium plume east of the 100-D Area.***

***Five-Year Review Actions***. The DOE continued several investigations in the 100-HR-3 Operable Unit that address items identified in a November 2006 CERCLA review.

- *Chromium Plume in the Horn*. The DOE installed wells and aquifer tubes to define the plume between 100-D and 100-H Areas, the region known as the "horn" of the Hanford Site. Data show that concentrations exceeding 20 µg/L extend across the horn.
- *Zero-Valent Iron Injection*. Scientists think that injecting tiny particles of iron into redox barrier wells will help "repair" the chromium breach in the barrier. Test injections occurred in August 2008. Initial results showed that the groundwater affected by the iron eliminates hexavalent chromium from the aquifer.
- *Electrocoagulation tests*. The DOE tested electrocoagulation for treating chromium-contaminated groundwater. Results indicated that the technology has the potential to meet the performance goal for groundwater treatment, but system operation was problematic.




***A pump-and-treat system in the 100-H Area has reduced the amount of chromium entering the Columbia River. Concentrations have decreased beneath the 100-H Area, but remain elevated in a plume to the west (upgradient).***

- *Chromium Source Investigation.* The DOE installed wells to obtain samples from the vadose zone and to monitor groundwater near suspected sources in the southern 100-D Area. Chromium levels in some of the wells were the highest ever observed in Hanford Site groundwater.

***Other research.*** The DOE conducted additional studies in FY 2008, including characterizing chromium geochemistry in the vadose zone and in situ biostimulation as a method of treating chromium contamination in groundwater.

## 100-HR-3-H Groundwater Interest Area

The eastern part of the 100-HR-3 Operable Unit (100-HR-3-H groundwater interest area) underlies the 100-H Area. Hexavalent chromium is the principal contaminant of concern in this area, but the plume is smaller and concentrations are lower than in the 100-D Area. Nitrate levels also are above background, but have declined from their peak historical levels. Strontium-90 exceeds the drinking water standard (8 pCi/L) beneath former retention basins. Technetium-99 and uranium concentrations are detected in a small area, but have been below drinking water standards in recent years.

***Chromium concentrations in 100-H Area have declined because of remediation and natural processes.***

***Interim Remedial Action.*** The chromium plume in the 100-H Area is the target of a pump-and-treat system. The remediation of the plume has removed ~51 kg of hexavalent chromium from the aquifer since 1997. Hexavalent chromium concentrations in compliance wells were mostly below the 22 µg/L remedial action goal in FY 2008.

***116-H-6 (183-H) Solar Evaporation Basins.*** These former basins are the only RCRA site in the 100-H Area. Leaks from the basins contaminated groundwater with chromium, nitrate, technetium-99, and uranium. Concentrations of all four contaminants were below drinking water standards in FY 2008. The site is monitored during the postclosure period to track contaminant trends during the operation of the CERCLA interim action for chromium.

## 100-FR-3 Operable Unit

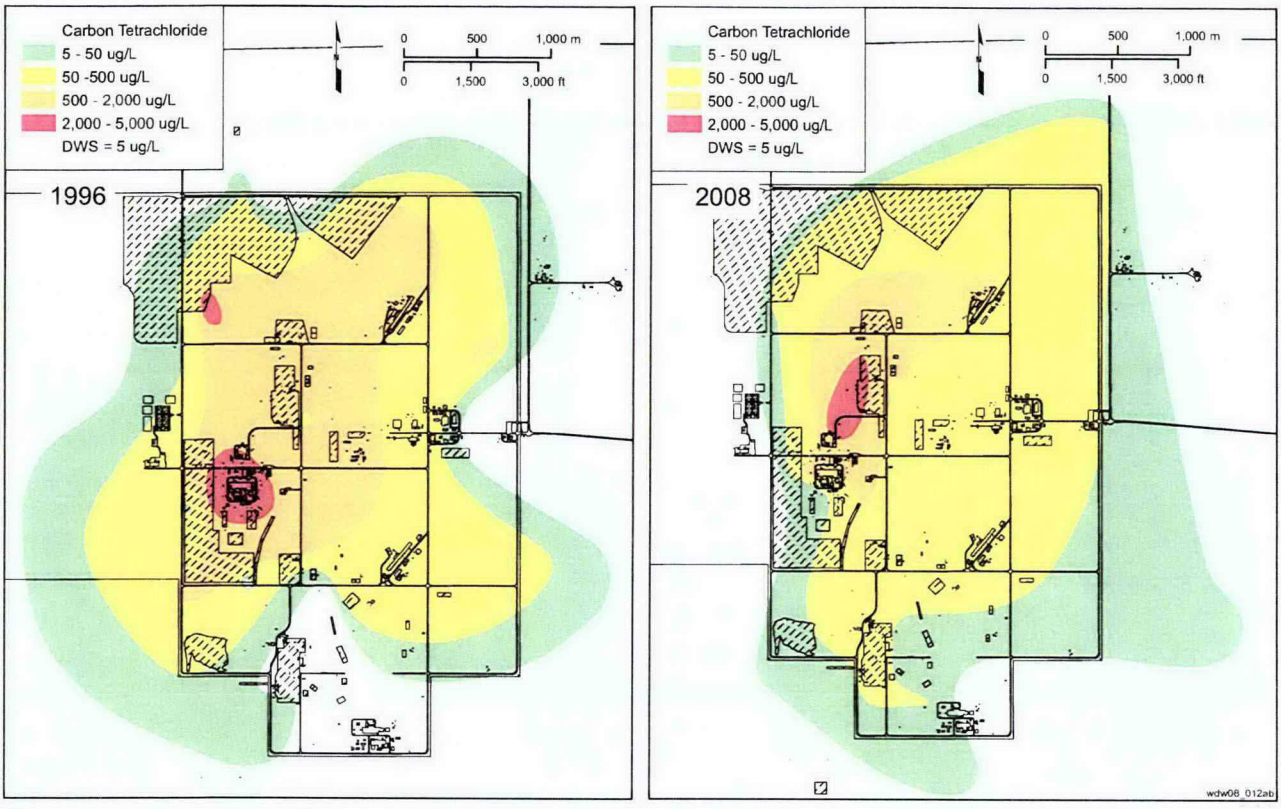
Nitrate concentrations in groundwater exceed the drinking water standard beneath much of the 100-F Area and the downgradient region. A few wells in the eastern 100-F Area have strontium-90 concentrations above the drinking water standard. Two wells in the southwestern 100-F Area exceed the standard for trichloroethene, but concentrations are declining steadily. Hexavalent chromium concentrations exceed the 10 µg/L aquatic standard in some wells.

During remediation of a burial ground in southwestern 100-F Area, the excavation reached the water table in one location and a small puddle of water formed. Samplers collected some of the water and strontium-90 was detected. The DOE installed a new monitoring well downgradient of the burial ground in FY 2008 and will begin sampling it in FY 2009.

A record of decision has not yet been developed for the 100-FR-3 Operable Unit and no active remediation of groundwater is underway. Monitoring contaminant conditions has continued since the initial remedial investigation and while waste site remedial actions are conducted.

## 200-ZP-1 Operable Unit

This operable unit encompasses the northern and central portions of the 200 West Area. The principal contaminant of concern is carbon tetrachloride. Other




***These maps show the carbon tetrachloride plume beneath the 200 West Area in the upper part of the unconfined aquifer. Since 1996, a pump-and-treat system in the 200-ZP-1 Operable Unit is helping prevent further spreading of the core of the plume.***

contaminants include tritium, nitrate, chloroform, chromium, fluoride, iodine-129, technetium-99, trichloroethene, and uranium.

In September 2008, the Tri-Parties signed a final record of decision for groundwater remediation in the 200-ZP-1 Operable Unit. The goal of the final remedy is to design and implement a remediation system to remove carbon tetrachloride and other contaminants throughout the vertical extent of the aquifer. Further expansion is planned as the final remedy is implemented.

***Final groundwater remediation in the 200-ZP-1 Operable Unit will include pump-and-treat and flow-path control.***

The final record of decision combines pump-and-treat, monitored natural attenuation, flow-path control through injection of treated water, and institutional controls. The pump-and-treat system will be designed to capture and treat contaminated groundwater to reduce the mass of carbon tetrachloride and co-contaminants throughout the operable unit by a minimum of 95% in 25 years.

Carbon tetrachloride contamination occurs at increasing depth to the east (downgradient) of the known source areas. In this area, natural and artificial recharge may have led to reduced carbon tetrachloride concentrations in the upper portion of the aquifer. Carbon tetrachloride is denser than water, which also affects its vertical distribution.

The 200-ZP-1 groundwater interest area contains one CERCLA interim action for groundwater, one remediation system for the vadose zone, four facilities monitored under RCRA (in conjunction with CERCLA and AEA), and one state-permitted unit.

***Interim Remedial Action.*** Since 1994, the DOE has operated an interim action pump-and-treat system to prevent carbon tetrachloride in the upper part of the aquifer from spreading. In FY 2008, four monitoring wells were converted to extraction wells, bringing the number of extraction wells to 14, with a combined pumping rate of approximately 1,514 L/min. In support of expansion activities, the pump-and-treat system was shut down in late May and, except for process and acceptance testing, remained offline the remainder of FY 2008. The system has removed 11,415 kg of carbon tetrachloride from groundwater since 1994.

***Groundwater and vadose zone remediation systems have removed over 90,800 kg of carbon tetrachloride from the subsurface.***

***Soil-Vapor Extraction.*** Soil-vapor is extracted from the vadose zone and treated to remove carbon tetrachloride. The system has removed ~79,400 kg of carbon tetrachloride from the vadose zone since operations started in 1991.

***Low-Level Burial Grounds Waste Management Area 3.*** RCRA groundwater monitoring continued under interim status requirements in FY 2008. The groundwater flow direction changed after liquid effluent discharges in 200 West Area ceased and water levels declined. The change left Low-Level Waste Management Area 3 without any upgradient wells. Until new upgradient wells are installed and background conditions are established, statistical evaluations have been suspended.

***Low-Level Burial Grounds Waste Management Area 4.*** RCRA groundwater monitoring continued under interim status requirements in FY 2008. The remaining upgradient wells went dry in FY 2008. Total organic carbon concentrations in one downgradient well exceeded the critical mean value in August 2008 and in a subsequent confirmatory sample. Groundwater will be monitored under an assessment program in FY 2009. Concentrations of the indicator parameter total organic halides have been affected by the regional carbon tetrachloride plume.

***Waste Management Area T.*** RCRA assessment monitoring continued in FY 2008. The waste management area has introduced technetium-99 and other tank waste constituents to the uppermost aquifer in the area. In September 2007, two downgradient wells on the east side of the tank farms were converted to extraction wells to remove technetium-99 from the aquifer. In FY 2008, technetium-99 concentrations decreased sharply in some downgradient wells and increased in others, most likely as a result of the extraction.

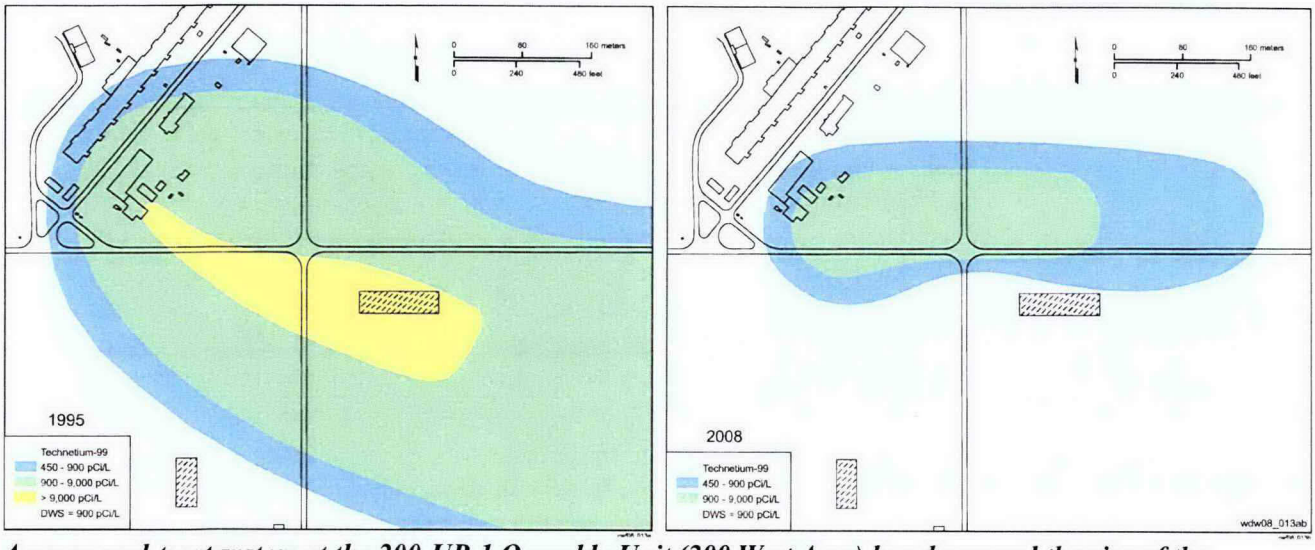
***Waste Management Area TX-TY.*** RCRA assessment monitoring continued in FY 2008. Sources in the waste management area have contaminated groundwater with chromium, technetium-99, and other tank waste constituents. Groundwater flow beneath Waste Management Area TX-TY is changing because of the operation of the 200-ZP-1 Pump-and-Treat Remediation System. Extraction wells operate south and west (upgradient) of the waste management area.

***A pump-and-treat system near U Plant has removed 2.4 Ci of technetium-99 and 218 kg of uranium from the groundwater.***

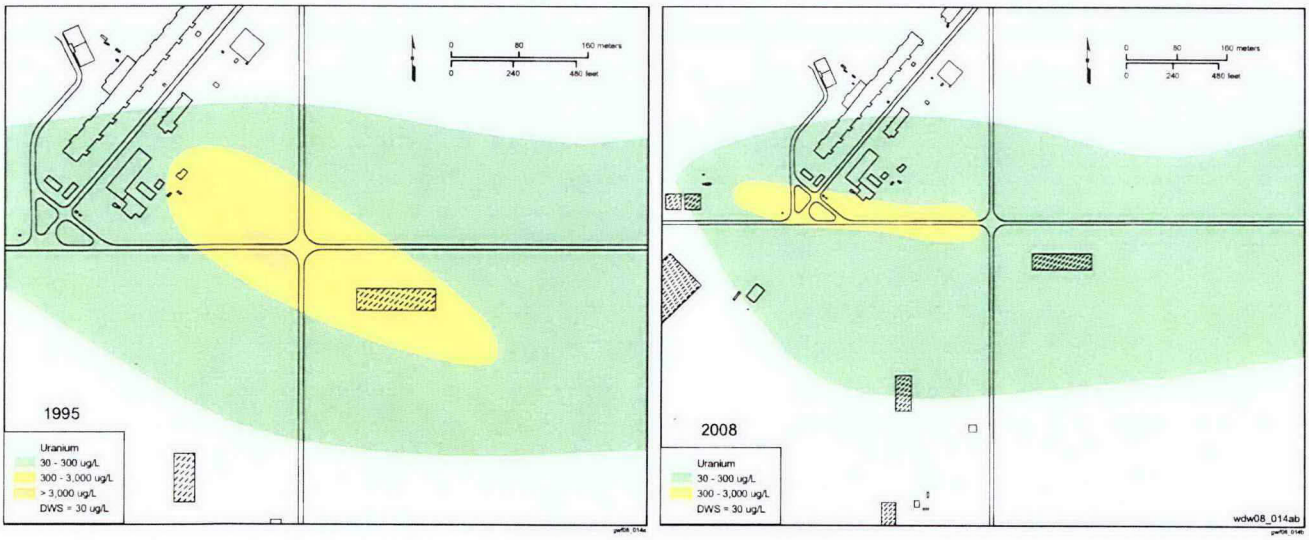
***State-Approved Land Disposal Site.*** This active disposal facility is regulated under a state waste discharge permit. Groundwater is monitored for tritium and 15 other constituents. Concentrations of all constituents considered in the permit did not exceed enforcement limits during FY 2008.

## 200-UP-1 Operable Unit

This operable unit underlies the south portion of 200 West Area. The principal contaminants of concern are technetium-99 and uranium. Tritium, chromium, iodine-129, and nitrate plumes also have sources in this operable unit. Carbon tetrachloride in the 200-UP-1 Operable Unit originated from sources in the 200-ZP-1 Operable Unit. Eight new monitoring wells were drilled in this operable unit in FY 2008.




***A pump-and-treat system at the 200-UP-1 Operable Unit (200 West Area) has decreased the size of the technetium-99 plume in the upper part of the aquifer. The system began to operate in fall 1995.***




***Uranium contamination in the 200-UP-1 Operable Unit (200 West Area) does not respond to the pump-and-treat system as quickly as technetium-99. Unlike technetium-99, uranium interacts with sediment grains, slowing its movement and response to remediation.***

The 200-UP-1 Operable Unit contains one CERCLA interim action, three facilities monitored under RCRA (in conjunction with CERCLA and AEA), and one CERCLA disposal site.

***Interim Remedial Action.*** The DOE operated an interim remedial action pump-and-treat system for technetium-99 and uranium from 1994 until early 2005. The effort successfully reduced contaminant concentrations below remedial action goals. The DOE shut down the system in January 2005 and conducted a rebound study. The remedial action goal for uranium was ten times the Washington State Model Toxics Control Act cleanup standard at the time the record of decision was issued, which was 48 µg/L. Since that time, EPA established a drinking water standard of 30 µg/L. In expectation that the remedial action goal will be revised to 300 µg/L (ten

times the current standard), the DOE resumed groundwater extraction in April 2007 and continue to operate it in FY 2008.

***Waste Management Area S-SX.*** RCRA assessment monitoring continued in FY 2008. Groundwater beneath this waste management area is contaminated with tank waste constituents, which include nitrate, chromium, and technetium-99 attributed to two general source areas within the waste management area. The highest technetium-99 concentrations in the operable unit occur in the southern plume, which represents a growing contamination issue because the plume is increasing in size. Each time the well with the highest concentrations is sampled (quarterly), extra groundwater is removed and treated to remove some technetium-99 from the groundwater. Chromium, nitrate, and technetium-99 concentrations also continued to increase in the northern plume at this waste management area.

***Waste Management Area U.*** RCRA assessment monitoring continued in FY 2008. The waste management area has been identified as the source of groundwater contamination that is limited to the downgradient (east) side of the site. Plume constituents of interest include nitrate and technetium-99.

***216-S-10 Pond and Ditch.*** The 216-S-10 Facility continued to be monitored under a RCRA interim status detection program in FY 2008. One upgradient well and two downgradient wells were installed in FY 2008 as part of the 200-UP-1 Operable Unit work plan, and also will be sampled as 216-S-10 Facility monitoring wells beginning in FY 2009.

***Environmental Restoration Disposal Facility.*** This facility is a low-level, mixed waste facility where waste generated from surface remedial actions and other activities on the Hanford Site is disposed. The site was built under CERCLA and is designed to meet all hazardous landfill standards. Results of groundwater monitoring continued to indicate that the facility has not adversely impacted groundwater quality. During FY 2008, two downgradient wells were decommissioned to allow for facility expansion to the east. Two new downgradient wells were constructed as replacements.

## 200-BP-5 Operable Unit

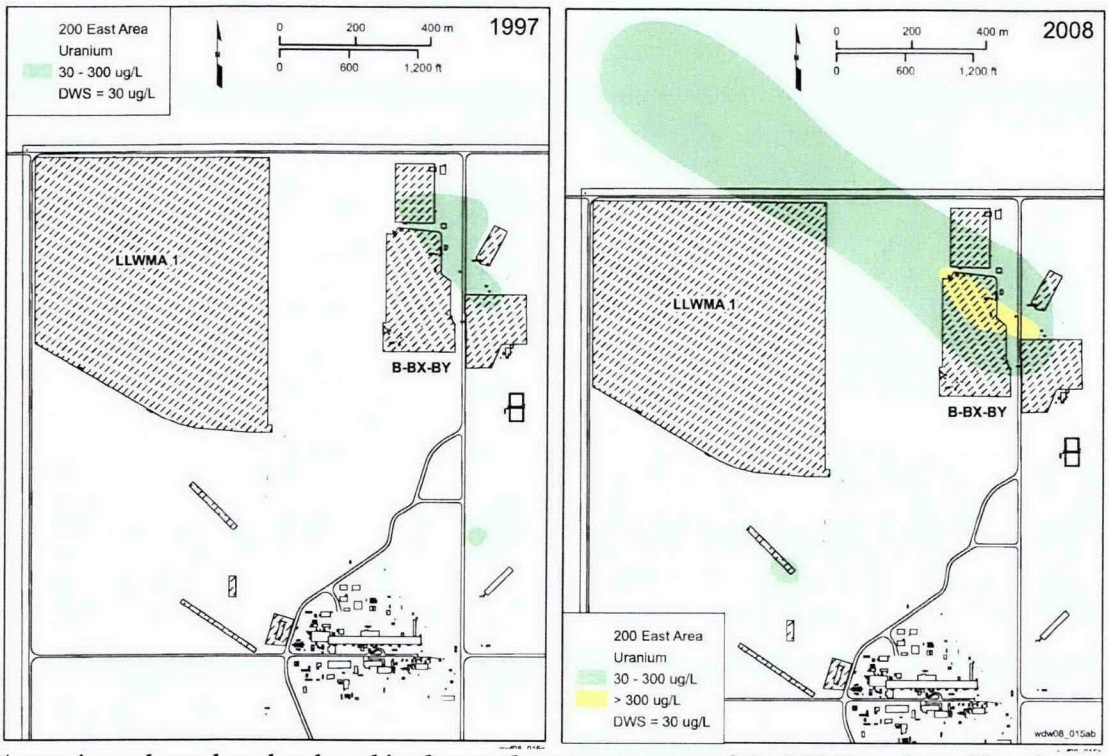
***The highest concentrations of technetium-99, uranium, cobalt-60, cesium-137, plutonium, cyanide, and nitrate on the Hanford Site in FY 2008 were in wells in the 200-BP-5 Operable Unit.***

This operable unit includes groundwater beneath the northern 200 East Area and the region to the northwest, where mobile contaminants, including tritium and technetium-99, historically moved northward between Gable Mountain and Gable Butte. Most of the groundwater contamination originated in facilities in the northwestern corner of the 200 East Area, known as the B Complex.

The water table in the northern 200 East Area is virtually flat, making it difficult to determine current directions of groundwater flow. Studies in recent years suggest that groundwater continues to flow slowly to the northwest from the B Complex area.

Technetium-99 and tritium plumes extend northward between Gable Mountain and Gable Butte. Uranium forms a narrow plume that extends northwest of the 200 East Area. Nitrate forms a plume that extends to the north and probably originated from multiple sources within the 200 East Area. Other contaminants include cesium-137, cobalt-60, cyanide, iodine-129, plutonium-239/240, strontium-90, sulfate, and uranium.

In FY 2008, the DOE continued to work on the 200-BP-5 Operable Unit remedial investigation/feasibility study. Drillers installed nine new wells.




***A uranium plume has developed in the northwestern corner of the 200 East Area. The plume appears to have sources in Waste Management Area B-BX-BY.***

Six facilities in the 200-BP-5 Operable Unit are monitored under RCRA in conjunction with CERCLA and AEA.

***Waste Management Area B-BX-BY.*** RCRA assessment monitoring continued at this site in FY 2008. Contaminants include uranium, technetium-99, and nitrate. A new well located on the northwestern corner of the B Tank Farm had the maximum uranium concentration in FY 2008.

***216-B-63 Trench.*** This RCRA site continued to be monitored under an interim status detection-monitoring program, with no indication that it has affected groundwater quality adversely.

***Low-Level Waste Management Area 1.*** This site continued to be monitored under RCRA interim status requirements. Specific conductance continued to exceed its critical mean value, but exceedances previously were reported and do not appear to indicate contamination from the waste management area.

***Low-Level Waste Management Area 2.*** This site continued to be monitored under RCRA interim status requirements, with no indication that it has affected groundwater quality adversely.

***Liquid Effluent Retention Facility.*** The water table has dropped into the fractured basalt flow top in all but two monitoring wells. The DOE and Ecology are pursuing an agreement for environmental monitoring. Two new wells were installed that monitor the fractured basalt flow-top and weathered zone.

***Waste Management Area C.*** This site continued to be monitored under an interim status RCRA detection program in FY 2008, but is sampled quarterly to meet requirements of a tank waste retrieval work plan. RCRA indicator parameters did

not exceed critical mean values, but specific conductance in one well is very close to the critical mean.

## 200-PO-1 Operable Unit

This operable unit encompasses the southern portion of the 200 East Area and a large region to the east and southeast that is contaminated with plumes of tritium and iodine-129. Concentrations of tritium continued to decline as the plume attenuates naturally because of radioactive decay and dispersion. Nitrate forms a large plume but mostly at levels below the drinking water standard. Other contaminants include strontium-90 and technetium-99, but these are limited to smaller areas.

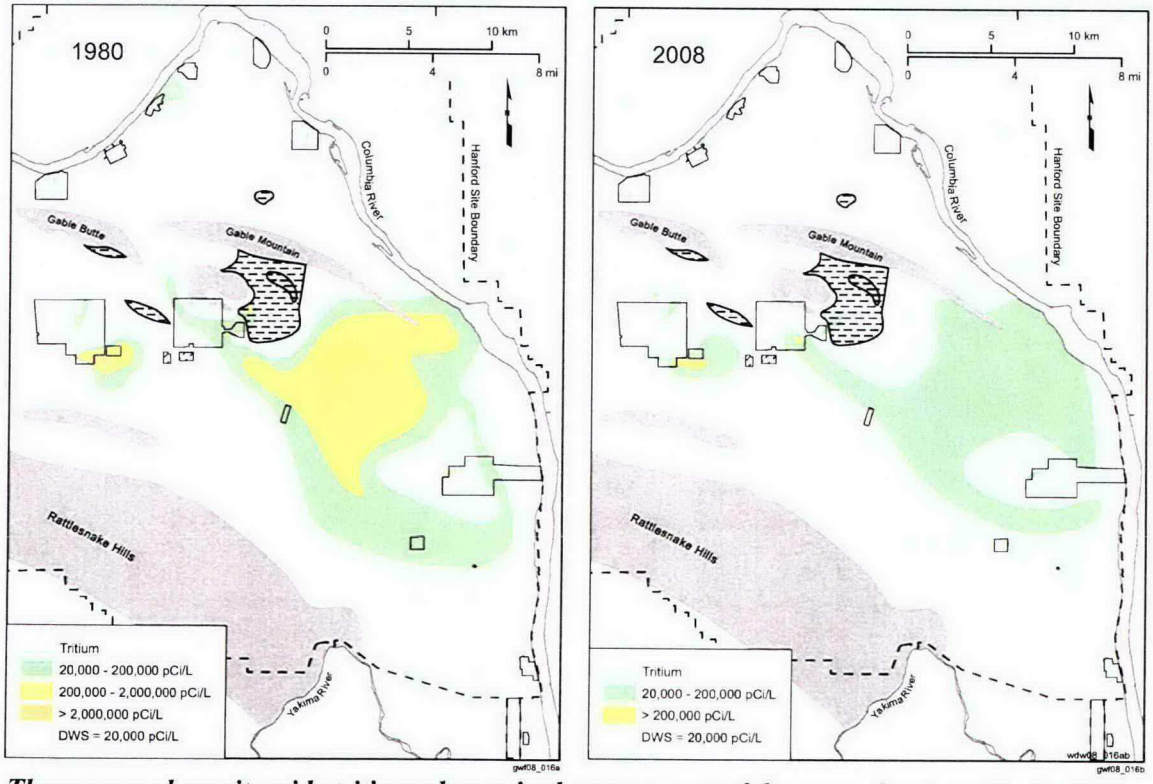
***The PUREX cribs contributed to plumes of iodine-129, nitrate, and tritium. Nitrate and tritium concentrations are generally declining.***

During FY 2008, the remedial investigation/feasibility study process generated a work plan. The document includes a sampling and analysis plan for routine groundwater monitoring of wells and a characterization sampling and analysis plan.

Groundwater is monitored at eight regulated units in the 200-PO-1 Operable Unit. Water supply wells in the 400 Area, which falls within the footprint of the 200-PO-1 Operable Unit, also are monitored.

***Integrated Disposal Facility.*** This facility will be an expandable, lined, RCRA-compliant landfill that will be used for disposal of low-level radioactive waste and hazardous waste. Until the facility begins to operate, results from semiannual monitoring will be added to the background data set.

***PUREX Cribs.*** The 216-A-10, 216-A-36B, and 216-A-37-1 Cribs are monitored jointly under a RCRA interim status assessment program, CERCLA, and AEA. The




***These maps show site-wide tritium plumes in the upper part of the unconfined aquifer in 1980 and 2008. Concentrations in the core of the plume have decreased over the years and the south margin is no longer spreading.***

cribs have contributed to widespread contaminant plumes in the area, including nitrate, tritium, and iodine-129. The nitrate and tritium plumes are generally attenuating throughout most of their area.

***Waste Management Area A-AX.*** RCRA assessment monitoring continued in FY 2008. Technetium-99 concentrations continued to exceed the drinking water standard (900 pCi/L) in two wells. A new downgradient well was installed in FY 2008 to replace two wells that had corroded, and were decommissioned.

***216-A-29 Ditch.*** The groundwater beneath this site continued to be monitored as required by RCRA interim status detection regulations, with no indication that it has affected groundwater quality adversely. Specific conductance remains elevated in three downgradient wells, but is consistent with regional groundwater chemistry.

***216-B-3 Pond.*** The groundwater beneath this site continued to be monitored as required by RCRA interim status detection regulations, with no indication that it has affected groundwater quality adversely.

***200 Area Treated Effluent Disposal Facility.*** A state waste discharge permit governs groundwater sampling and analysis in the three monitoring wells at this facility. No permit criteria for constituents in groundwater were exceeded in FY 2008. Because no unconfined aquifer exists beneath the facility, groundwater monitoring wells are installed in the locally confined aquifer below the Ringold Formation lower mud unit.

***Nonradioactive Dangerous Waste Landfill.*** This RCRA site is located in the 600 Area, within the footprint of the 200-PO-1 Operable Unit regional plume. Interim status detection monitoring continued FY 2008. Total organic carbon concentrations in one downgradient well exceeded the critical mean value in August 2008 and in a confirmatory sample in October 2008. Groundwater will be monitored under an assessment program in FY 2009.

***Solid Waste Landfill.*** This facility is adjacent to the Nonradioactive Dangerous Waste Landfill and is regulated under state solid waste regulations. As in previous years, some downgradient wells showed higher chemical oxygen demand, chloride, coliform bacteria, specific conductance, sulfate, total organic carbon, and lower pH than upgradient wells. Some of these constituents may be related to past disposal of sewage materials to the landfill.

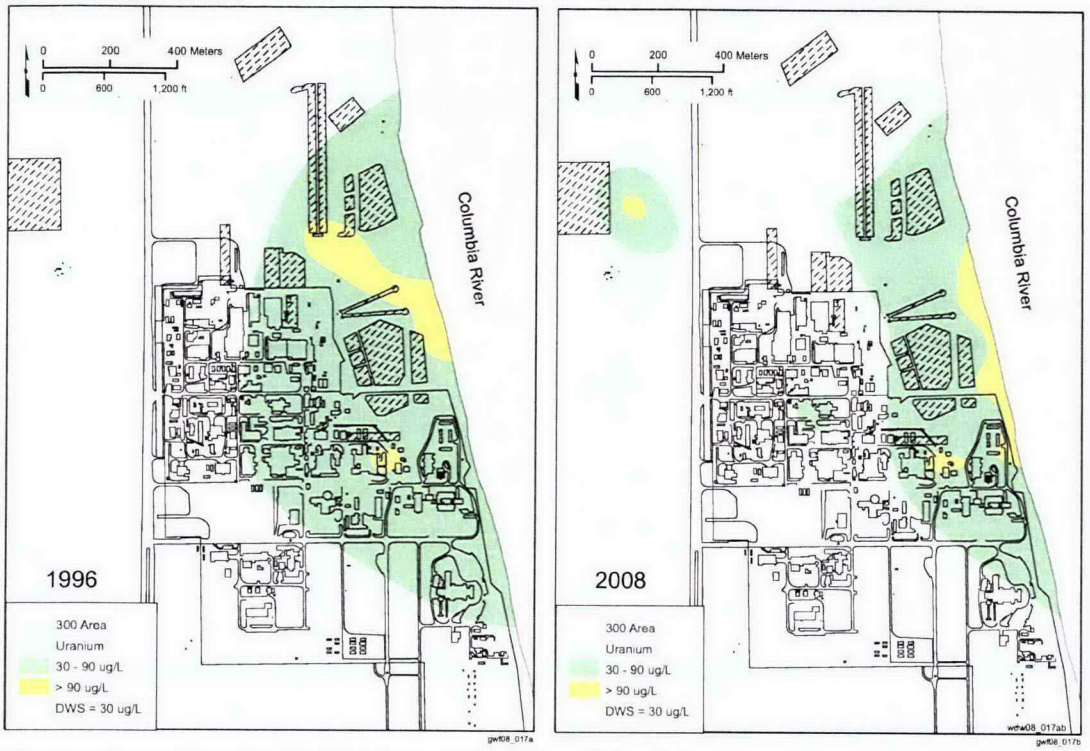
***400 Area Water Supply Wells.*** Three water supply wells provide drinking water and emergency supply water for the 400 Area. Because the 400 Area is in the path of the site-wide tritium plume, the wells are routinely monitored for tritium. Tritium concentrations in all samples were below the drinking water standard in FY 2008.

## 300-FF-5 Operable Unit

***The DOE is investigating remediation methods for uranium in the 300 Area.***

This operable unit includes three geographic regions: the 300 Area, the 618-11 Burial Ground region, and the 618-10 Burial Ground/316-4 Cribs region. The operable unit is currently regulated under an interim record of decision that calls for groundwater monitoring and institutional controls on the use of groundwater. In FY 2008, the DOE installed 35 wells to characterize uranium geochemistry and mobility, and 3 wells to define trichloroethene distribution.

Recent work in this operable unit included updating computer simulations of groundwater flow and uranium transport; conducting a limited field investigation of uranium involving multiple characterization boreholes; updating to the human health and ecological risk assessment; and conducting an assessment of potential remedial




***The uranium plume in the 300 Area, at the 30 µg/L level, is attenuating slowly. The DOE is investigating alternatives for more rapid remediation.***

action technologies for the 300 Area uranium plume. Many of these additional activities essentially were completed during FY 2008. Continuing work will be conducted for interim action monitoring and characterization activities, and systematic planning of a new work plan for continued remedial investigation and feasibility study activities. These activities are intended to develop information that will lead to a proposed plan for final remediation efforts.

Contaminants of concern in 300 Area groundwater are uranium, trichloroethene, and cis-1,2-dichloroethene. Monitoring and plume characterization activities indicate relatively constant or gradually decreasing levels for these contaminants. Uranium is the principal contaminant of concern and remains above the drinking water standard (30 µg/L) beneath part of the 300 Area. Trichloroethene continued to be below the 5 µg/L drinking water standard in wells monitoring the top of the unconfined aquifer. However, higher concentrations were detected in a deeper, fine-grained unit in a limited area.

***Tritium concentrations continued to decline downgradient of the 618-11 Burial Ground.***

Groundwater downgradient of the 618-11 Burial Ground is contaminated by a high-concentration tritium plume, probably originating from irradiated material in the burial ground. Concentrations at a well adjacent to the burial ground have decreased from greater than 8 million pCi/L in 2000 to 780,000 pCi/L in September 2008.

***300-FF-5 Operable Unit Phase III Feasibility Study.*** Because the uranium plume beneath the 300 Area has not decreased in concentration as rapidly as predicted by earlier studies, the DOE continued a detailed investigation of the natural processes that cause the plume to persist and the residual sources that may supply uranium to the plume. Results did not reveal evidence for high levels of uranium in the vadose zone, nor for a zone of elevated contaminants near the water table. Also, water samples collected from the saturated zone at various depths confirmed that contamination is

generally limited to the uppermost hydrologic unit (i.e., saturated Hanford gravels). Concentrations in the samples were consistent with those observed during routine groundwater monitoring.

***Uranium Treatability Test.*** In FY 2008, the DOE monitored results of a treatability test to immobilize uranium in the aquifer. The test, conducted in FY 2007, involved injecting polyphosphate into the aquifer. Monitoring during FY 2008 indicated that the method has not performed as well as hoped in permanently sequestering uranium on aquifer solids. The heterogeneity in aquifer sediment and dynamic nature of hydrologic conditions present challenges to potential in situ remedies.

***Integrated Field-Scale Research Challenge.*** This basic research project has focused on the geochemistry and mobility of uranium in the vadose zone at the 300 Area. Initial field activities included drilling 35 characterization boreholes at a location with a good potential of encountering residual uranium in the vadose zone. Geophysical investigations associated with this research project also continued during FY 2008.

***316-5 Process Trenches.*** This former liquid waste disposal site was the last in the 300 Area to receive uranium-bearing effluent, with discharges ending in the early 1990s. The site, which has been remediated, is regulated under RCRA in conjunction with CERCLA and AEA. Uranium currently exceeds the drinking water standard in wells downgradient from the waste site, although concentrations appear to be decreasing with time. Cis-1,2-dichloroethene concentrations exceed the standard at only one downgradient well completed near the bottom of the aquifer.

## 1100-EM-1 Groundwater Interest Area

The 1100-EM-1 groundwater interest area is located in the southern part of the Hanford Site. It includes the former 1100-EM-1 Operable Unit, which was recently removed from the National Priorities List (40 CFR 300, Appendix B) and is no longer classified as a CERCLA operable unit. Groundwater also is monitored south of the Hanford Site, including the areas formerly designated as the 1100 and 3000 Areas of the Hanford Site, the city of Richland's landfill, and the North Richland Well Field.

***In the 1100-EM-1 groundwater interest area, trichloroethene concentrations continued to be below the cleanup level.***

Trichloroethene was the principal contaminant of concern in the operable unit. Contaminants also flow into the area from offsite sources (e.g., nitrate from agriculture and industry). The final remedy selected for 1100-EM-1 Operable Unit groundwater was monitored natural attenuation of volatile organic compounds. Concentrations of trichloroethene have remained below the drinking water standard since FY 2001.

Wells in the North Richland Well Field are monitored frequently to detect any changes in Hanford Site contaminants near these wells. The tritium plume originating from sources in the 200 East Area has not been detected in these wells. Low levels of tritium, similar to those detected in Columbia River water, continued to be detected.

Elevated levels of gross alpha occur downgradient of an offsite industrial facility. If gross alpha is attributed to uranium, then uranium exceeded the 30 μg/L drinking water standard. Uranium concentrations in wells downgradient of the DOE's inactive Horn Rapids Landfill have been increasing since 1996, but remained below the standard in FY 2008.

### Confined Aquifers

Although most of the Hanford Site's groundwater contamination is in the unconfined aquifer, the DOE monitors wells in deeper aquifers because of the potential for downward migration of contamination and the potential migration of contamination off Site through the basalt confined aquifer. No evidence of offsite migration via the confined aquifer has been detected.

*Technetium-99, cyanide, and nitrate were elevated in a new basalt-confined well. The contamination migrated down an old, poorly-constructed well nearby, in the past.*

The Ringold Formation confined aquifer occurs within fluvial sand and gravel comprising the lowest sedimentary unit of the Ringold Formation. It is confined below by basalt and above by the Ringold lower mud unit. While effluent disposal was occurring at the B Pond System, mounding within the unconfined aquifer in this area led to downward migration of groundwater into the Ringold Formation confined aquifer. During FY 2008, seven wells were sampled that are completed in the Ringold Formation confined aquifer. No contaminants exceeded primary drinking water standards.

Within the upper basalt-confined aquifer system, groundwater occurs within basalt fractures and joints, interflow contacts, and sedimentary interbeds. In FY 2008, six basalt-confined aquifer wells were sampled. Tritium continued to be detected at low levels in some basalt-confined wells. One elevated tritium concentration near the 200 East Area is associated with intercommunication between the upper basalt-confined aquifer and the overlying unconfined aquifer. Iodine-129, strontium-90, gamma-emitting isotopes, and uranium isotopes were not detected above the minimum detection limits in the upper basalt-confined aquifer. One new well monitoring the upper basalt-confined aquifer in the northwestern part of the 200 East Area shows contamination with technetium-99, cyanide, and nitrate. Migration of high-salt waste from the vadose zone or unconfined aquifer via an older, poorly-constructed well nearby is responsible for this contamination. The old well has been sealed.

## Shoreline Monitoring

The DOE monitors groundwater near the Columbia River via aquifer tubes, which are small diameter, flexible tubes that are implanted in the shallow aquifer and natural seep points or springs.

*The DOE samples groundwater near the Columbia River via aquifer tubes and springs.*

Concentrations of strontium-90 continued to exceed the 8 pCi/L drinking water standard in aquifer tubes in the 100-B/C, 100-N, and 100-H Areas. Levels exceed the 1,000 pCi/L derived concentration guide in 100-N Area tubes, reaching 75,000 pCi/L in one tube in July 2008. This high concentration represented a brief spike in response to the nearby injection of apatite-forming chemicals.

Tritium concentrations exceeded the 20,000 pCi/L drinking water standard in one tube at the upstream end of 100-D Area. The source is believed to be the 100-N Area plume. Tritium also exceeded the standard in springs and aquifer tubes at the Hanford townsite.

Uranium concentrations exceed the 30 μg/L drinking water standard in aquifer tubes and springs in the 300 Area.

Hexavalent chromium concentrations exceeded the 100 μg/L drinking water standard in 100-D Area aquifer tubes. Concentrations in aquifer tubes or springs exceeded the 10 μg/L aquatic standard in the 100-B/C, 100-K, 100-D, 100-H, and 100-F Areas.

Nitrate concentrations exceeded the 45 mg/L drinking water standard in aquifer tubes in the 100-K, 100-N, and 100-H Areas. An aquifer tube in the southern 300 Area also exceeded the standard; the source of this nitrate is a plume from sources off the Hanford Site.

Trichloroethene is detected in several aquifer tubes in the 300 Area and continued to exceed the 5 μg/L drinking water standard in some tubes that monitor a fine-grained unit.

## Vadose Zone

Vadose zone activities in FY 2008 included leachate monitoring, soil-vapor extraction and monitoring, surface geophysics, and borehole geophysical logging.

***Leachate Monitoring at Environmental Restoration Disposal Facility.*** This facility is used for disposal of radioactive and mixed waste generated during waste management and remediation activities at the Hanford Site. Leachate is collected and sent to the Effluent Treatment Facility. The composite leachate samples contained detectable concentration of common metals, anions, and mobile radionuclides. Constituents that were generally increasing in concentration include gross alpha and total uranium. Gross alpha concentrations in groundwater show a slight long-term decrease and gross beta concentrations show an increase in most downgradient wells. Gross alpha and gross beta in groundwater will be closely monitored in the future.

***Leachate and Soil-Gas Monitoring at the Solid Waste Landfill.*** Leachate is sampled and tested quarterly. Concentrations in the past year were similar to previous concentrations and did not identify any areas of concern. Soil gas is monitored quarterly to determine concentrations of oxygen, carbon dioxide, methane, and several key volatile organic compounds. Results were consistent with previous years. Contaminants of concern were near or below detection limits.

***Soil-Vapor Extraction.*** This remedial action is being used to remove carbon tetrachloride from the vadose zone in the 200 West Area. As of September 2008, ~79,400 kg of carbon tetrachloride have been removed from the vadose zone since extraction operations started in 1991.

***As of September 2008, ~79,400 kg of carbon tetrachloride have been removed from the vadose zone since extraction operations started in 1991.***

***Tank Farm Vadose Zone Activities.*** The Vadose Zone Integration Program is responsible for implementing the Tank Farm RCRA Corrective Action Program through field characterization, laboratory analyses, technical analyses, risk assessment for past tank leaks, and application of interim measures that will reduce the threat from contaminants until permanent solutions can be found. In FY 2008, the Vadose Zone Integration Program installed several direct push boreholes for soil sampling and geophysical logging in the C and TY Tank Farms, completed surface geophysical surveys at Waste Management Area TX-TY, and conducted a well-to-well geophysical survey of the SX Tank Farm. An interim surface barrier was completed over a portion of the T Tank Farm to reduce the infiltration of precipitation through the remnants of a 1973 tank leak.

## Well Installation, Maintenance, and Decommissioning

***During FY 2008, the DOE installed 113 new wells and decommissioned 103 wells.***

The DOE installs new wells when needed for monitoring or characterization, maintains wells to repair problems, and decommissions wells that could no longer be used. Ecology, EPA, and DOE worked together to develop a prioritized list of new

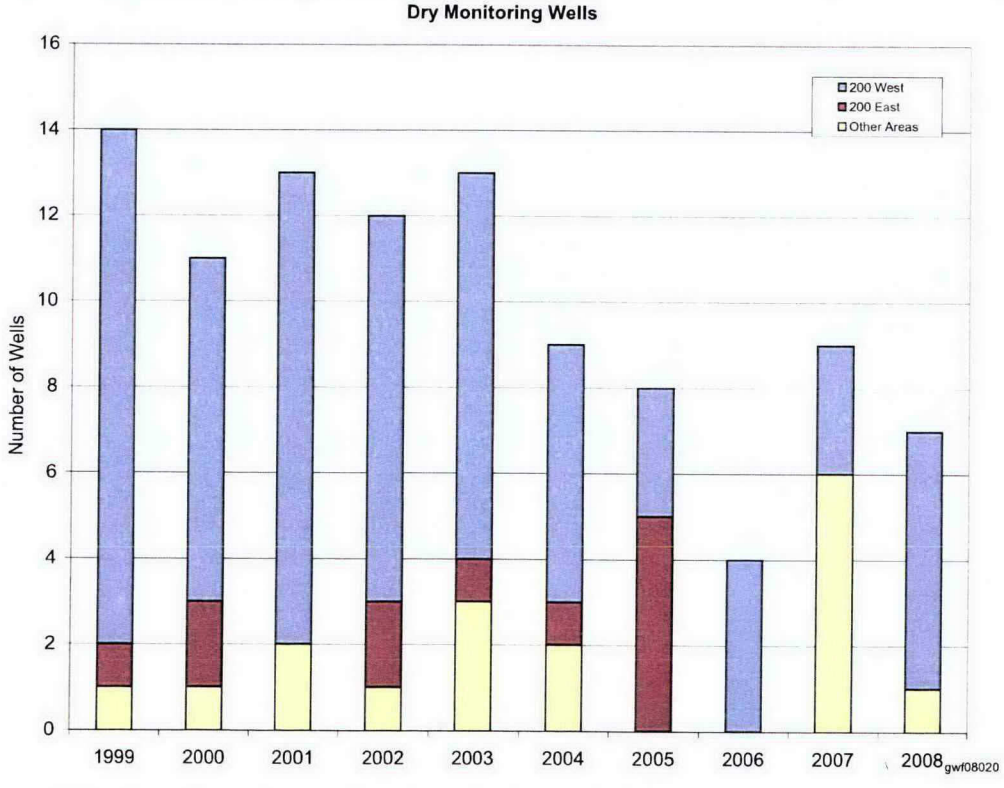
wells needed to meet requirements of various groundwater monitoring regulations. In FY 2008, the DOE installed 113 new wells.

During FY 2008, 386 temporary characterization boreholes were installed around the Hanford Site to support various projects. The temporary boreholes are installed for subsurface characterization of radiological constituents, volatile organics (e.g., carbon tetrachloride), or hydrogeologic property determination (e.g., moisture, grain size distribution). While typically installed to characterize the vadose zone, borings can be drilled to groundwater to obtain a one-time sample and then be decommissioned.

**Wells Installed in FY 2008.**

| Location (Facility) | Number of New Wells |
|---|---|
| 100-FR-3 | 1 |
| 100-HR-3 Horn | 15 |
| 100-HR-3-D | 4 |
| 100-KR-4 | 27 |
| 100-NR-2 | 6 |
| 200-BP-5 | 8 |
| 200-BP-5 (LERF) | 1 |
| 200-PO-1 (WMA A-AX) | 1 |
| 200-UP-1 | 4 |
| 200-UP-1 (216-S-10) | 2 |
| 200-UP-1 (ERDF) | 2 |
| 200-ZP-1 | 3 |
| 200-PW-1 (soil-vapor) | 1 |
| 300-FF-5 | 38 |
| Total | 113 |

Approximately 9,695 unique well identification numbers have been identified within the Hanford Site. These include all wells, characterization boreholes, aquifer tubes, soil gas probes, piezometers, or other subsurface installations. To date, 4,272 (~44%) of these have been either administratively removed from the well inventory or decommissioned (sealed with grout). Wells are decommissioned when they are no longer needed; are in poor condition; are in the path of intended remediation or construction activities; or pose an environmental, safety, or public health hazard. The DOE maintains a list of wells that are candidates for decommissioning. All candidate wells must be reviewed and approved by potential well users prior to decommissioning. During FY 2008, a total of 3,384 unique well identification numbers were documented as "in use." A total of 103 wells were physically decommissioned during FY 2008 and 221 temporary boreholes were administratively decommissioned by records management.




***This chart shows the number of monitoring wells that went dry each year since 1999. Most of the wells were in the 200 West Area, where the water table declined the most.***

Staff performed maintenance on 275 wells in FY 2008. Surface maintenance includes labeling wells, maintaining well caps, and repairing surface casing, wiring, or pump-discharge fittings. Subsurface tasks include repairing and replacing sampling pumps, performing camera surveys, retrieving pumps and equipment, and replacing tubing.

## Continued Monitoring

The DOE will continue to monitor groundwater to meet the requirements of AEA, CERCLA, RCRA, and DOE Orders. During ongoing groundwater remediation, the groundwater project will monitor, assess, and report on activities at groundwater operable units. Both the unconfined and upper-confined aquifers are monitored and data are maintained and managed in a centralized database. Monitoring well locations, frequencies, and analytical constituents will continue to be documented each year. Water-level monitoring will continue to be performed to characterize groundwater flow and to determine the impact of Hanford Site operations on the flow system.

Groundwater monitoring remains a part of the Hanford Site baseline throughout the cleanup mission and will remain a component of long-term stewardship after remediation is completed.

Details about the Hanford Site Groundwater Remediation Project can be found online at http://www.hanford.gov/cp/gpp/.

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# 1.0 Introduction

*M. J. Hartman*

The Hanford Site, part of the U.S. Department of Energy's (DOE) nuclear weapons complex, encompasses ~1,500 km$^2$ in southeastern Washington State. The Columbia River flows through the Site. The federal government acquired the Hanford Site in 1943 and until the 1980s used it to produce plutonium for national defense. Management of waste associated with plutonium production has been a major activity throughout the Site's history and continues today at a much reduced scale. Beginning in the 1990s, the DOE has focused on cleaning up the Site.

The DOE is committed to protecting the Columbia River from the Site's contaminated groundwater. Groundwater is the primary exposure route for Site contaminants to reach human and environmental receptors. DOE/RL-2007-20, *Hanford Integrated Groundwater and Vadose Zone Management Plan*, lays out steps for addressing groundwater and vadose zone contamination. The DOE developed the plan in consultation with the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology). The primary elements associated with managing the Hanford Site's groundwater and vadose zone are (a) to protect the Columbia River and groundwater; (b) to develop a cleanup decision process, and (c) to attain final cleanup.

***The DOE's groundwater strategy focuses on protecting groundwater from contaminants, monitoring groundwater conditions, and cleaning up contaminated groundwater.***

***Protect the Columbia River and groundwater.*** Many actions have already been taken to address principal threats to the Columbia River and groundwater. These actions include the following:

- Cease discharge of all unpermitted liquids in the central Hanford Site
- Remediate the former liquid waste sites in the 100 and 300 Areas to reduce potential for future contamination to groundwater
- Contain groundwater plumes and reduce mass of primary contaminants through remedial actions such as pump-and-treat.

***Develop a process for cleanup decisions.*** Final decisions will be based on processes outlined in *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) and/or *Resource Conservation and Recovery Act of 1976* (RCRA). The following five key elements will support final decisions:

- Gather sufficient characterization data, focusing on waste sites with deep contamination that post a future risk to groundwater

***This report is designed to meet the following objectives.***

- ***Provide a comprehensive report of groundwater conditions on the Hanford Site.***
- ***Fulfill the reporting requirements of RCRA, CERCLA, AEA, and Washington Administrative Code.***
- ***Summarize the results of groundwater monitoring conducted to assess the effects of interim remedial actions conducted under CERCLA.***
- ***Describe the results of monitoring the vadose zone.***
- ***Summarize the installation, maintenance, and decommissioning of Hanford Site monitoring wells.***

- Evaluate the performance of early actions (waste site remediation along the River Corridor and groundwater interim actions) to help guide future cleanup
- Identify cleanup goals for waste sites that support long-term groundwater remediation
- Identify new technologies to reduce mobility of deep contamination and limit its movement to groundwater
- Improve integration of cleanup decisions for waste sites and groundwater.

***Attain final cleanup.*** The DOE, EPA, and Ecology are committed to completing cleanup of past-practice waste sites by September 2024. Substantial progress has been made toward cleanup of the 100 and 300 Areas. Strategies used for making final decisions in the 100 and 300 Areas will provide a basis for attaining similar final decisions for the 200 Area.

Groundwater monitoring fulfills a variety of state and federal regulations, including the *Atomic Energy Act to 1954* (AEA), CERCLA, RCRA, and *Washington Administrative Code.*

## 1.1 Purpose and Scope

This document presents results of groundwater monitoring to meet the requirements of the AEA, RCRA, and those CERCLA groundwater operable units where cleanup decisions have not yet been made (Table 1.0-1). Other CERCLA groundwater operable units have independent reporting requirements and this document summarizes results reported elsewhere. This report also summarizes vadose zone monitoring and well installation activities. The report covers the period from October 1, 2007, through September 0, 2008 (i.e., fiscal year [FY] 2008). Appendix A lists supporting information for CERCLA monitoring. Appendix B contains tables and figures that support RCRA and other facility monitoring. Table 1.0-2 lists the status of RCRA monitoring for each monitored unit in FY 2008.

Background information, including descriptions of regulatory requirements, waste sites, analytical methods, regional geology, and statistics is published separately in a companion volume, PNNL-13080, *Hanford Site Groundwater: Settings, Sources, and Methods*, and in the most recent update, which was provided in PNNL-13788, *Hanford Site Groundwater Monitoring for Fiscal Year 2001*, Appendix C.

## 1.2 Groundwater Monitoring

***During FY 2008, staff sampled 865 wells and 297 aquifer tubes for radiological and chemical constituents.***

Waste sites are grouped into source operable units, and the groundwater is divided into groundwater operable units. The concept of operable units is to group the waste sites into manageable components for investigation and to prioritize the cleanup work. The groundwater operable units do not cover the entire Hanford Site. To provide scheduling, data review, and interpretation for the entire Site, groundwater staff have defined informal groundwater interest areas that include the groundwater operable units and intervening regions. Figure 1.0-1 illustrates these interest areas and the operable unit boundaries.

Various documents (i.e., monitoring plans or sampling and analysis plans) define which wells to sample, how frequently, and which constituents to analyze.

These choices are based on the data needs for various monitoring purposes, such as complying with regulations, evaluating the performance of remediation, defining plumes and concentration trends, or identifying emerging problems.

During FY 2008, Hanford Site staff sampled 865 wells, approximately the same number as in FY 2007. Staff sampled 297 aquifer tubes in FY 2008, a 50% increase from FY 2007. Many of the sites were sampled multiple times, for a total of 2,601 sampling trips. These numbers do not include special groundwater sampling associated with remediation and research (e.g., treatability tests).

Most of the monitoring wells on the Hanford Site are screened near the top of the unconfined aquifer. In most regions, the shallow part of the aquifer is the most contaminated. Contaminant plume maps and plume area calculations in this report are based on data from the top of the aquifer. Some contaminants, most notably carbon tetrachloride, are denser than water and can be more widespread deeper in the aquifer. Downward hydraulic gradients also may increase contamination at depth. Studies of contaminant distribution with depth are beginning to be conducted for some plumes, especially those in the 200 West Area.

***Tritium, nitrate, and iodine-129 are the most widespread contaminants on the Hanford Site.***

Chromium (total or hexavalent) was the most frequently analyzed constituent. Anions, tritium, gross alpha, gross beta, iodine-129, metals, technetium-99, strontium-90, and volatile organic compounds were other commonly analyzed constituents (Table 1.0-3).

Tritium, nitrate, and iodine-129 are the most widespread contaminants associated with past Hanford Site operations. Figures 1.0-2 through 1.0-4 show their distribution in the upper unconfined aquifer. The most prominent portions of these plumes originated at waste sites in the 200 Area and spread toward the southeast. Nitrate and tritium also had significant sources in the 100 Area.

Table 1.0-4 lists maximum concentrations of selected groundwater contaminants in each groundwater interest area. Electronic data files accompany this report and include FY 2008 and historical data.

Groundwater monitoring objectives of RCRA, CERCLA, and AEA often differ slightly, and the contaminants monitored are not always the same. For RCRA-regulated units, monitoring focuses on nonradioactive dangerous waste constituents. Radionuclides (source, special nuclear, and by-product materials) may be monitored in some RCRA unit wells to support objectives of monitoring under AEA and/or CERCLA. Please note that pursuant to RCRA, the source, special nuclear, and by-product material components of radioactive mixed waste are not regulated under RCRA and are regulated by the DOE acting pursuant to its AEA authority. Therefore, while this report may be used to satisfy RCRA reporting requirements, the inclusion of information on radionuclides in such a context is for information only and may not be used to create conditions or other restrictions set forth in any RCRA permit.

## 1.3 Shoreline Monitoring

The DOE monitors groundwater quality along the river by collecting samples from aquifer tubes and riverbank seeps (springs). Hydrologists estimate that groundwater currently flows from the Hanford Site aquifer to the Columbia River at a rate between 1.1 and 2.5 $m^3$/sec (PNNL-13447; PNNL-14753). This rate is less than 0.075% of the average flow of the Columbia River, ~3,400 $m^3$/sec.

The rise and fall of the river create a zone of interaction that influences contaminant concentrations and groundwater flow patterns. Water samples from aquifer tubes and riverbank seeps nearly always represent a mixture of river water and approaching groundwater. In general, the degree of dilution by river water decreases with depth in the aquifer near the river shoreline. The degree of dilution also varies by location and with seasonal river cycles (PNNL-13674, *Zone of Interaction Between Hanford Site Groundwater and Adjacent Columbia River*).

***Monitoring groundwater quality along the Columbia River is accomplished by collecting samples from aquifer tubes and riverbank springs.***

Data from aquifer tubes and seeps are used for the following purposes.

- In mapping, data indicate minimum concentrations of contaminants in groundwater approaching the river (because the samples may be mixed with river water, actual concentrations in groundwater may be higher). However, if a group of tubes routinely shows no contamination, it is likely that the groundwater near the river is clean.
- Long-term declines in contamination in aquifer tubes or seeps may indicate a real trend in groundwater. The decline could represent movement of the plume, dispersion, or the influence of an upgradient remediation system. Increasing concentrations may indicate plume movement or mobilization of contaminants.
- Data from aquifer tubes have helped determine where additional monitoring and remediation are needed (e.g., aquifer tube data provided the first indication of the southern 100-D Area chromium plume).

Interpreters of these data must keep in mind the following limitations.

- Concentrations may vary seasonally.
- Because aquifer tubes have a much shorter screen interval than monitoring wells, the data may not be directly comparable to data from near-river wells.
- Aquifer tube and seep data currently are not used in remedial action decision making (i.e., are not compliance points for pump-and-treat systems).

### 1.3.1 Aquifer Tubes

Aquifer tubes are small-diameter flexible tubes that have a screen at the lower end. The tubes are implanted into the aquifer along the Columbia River shore by driving a temporary steel casing into the ground and inserting a tube with attached screen into the casing. The steel casing is then pulled out, leaving the tube in place. Water is withdrawn from the tube using a small pump. Most tube sites include two or three individual tubes monitoring different depths from ~1 to 8 m.

Representatives from the EPA and Ecology meet annually with the DOE and its contractors to plan the annual sampling event, which usually occurs during the fall months (DOE/RL-2000-59, *Sampling and Analysis Plan for Aquifer Sampling Tubes*). An upcoming report will present aquifer tube results for FY 2008. The individual operable unit sections of this report summarize aquifer tube results and include location maps.

***In FY 2008, the DOE installed 139 new aquifer tubes at 61 locations along the shoreline.***

In FY 2008, the DOE installed 139 new aquifer tubes at 61 locations from the 100-B/C Area to the 300 Area. Two hundred ninety-seven tubes at 150 locations were sampled in FY 2008.

Table 1.0-4 lists maximum contaminant levels in aquifer tubes sampled in FY 2008. Concentrations of strontium-90 exceed the 8 pCi/L drinking water standard in aquifer tubes in the 100-BC-5, 100-NR-2, and 100-H Areas. Levels exceed the 1,000 pCi/L DOE derived concentration guide in 100-N Area tubes. Concentrations are highest in shallow or mid-depth tubes. This reflects the distribution of strontium-90 near the top of the aquifer in the 100 Area.

Hexavalent chromium exceeded the 100 µg/L drinking water standard in 100-D Area aquifer tubes, and exceeded the 10 µg/L aquatic standard (WAC 173-201A) in tubes in each of the 100 Areas (Figure 1.0-5), except 100-N Area. Concentrations are generally highest in deeper tubes because samples are less diluted with river water.

Nitrate concentrations exceeded the 45 mg/L drinking water standard in aquifer tubes at the 100-K, 100-N, and 100-H Areas in FY 2008. An aquifer tube in the southern 300 Area also exceeded the standard. The source of the nitrate is a plume from location off the Hanford Site.

Trichloroethene is detected in several aquifer tubes in the 300 Area and continued to exceed the 5 µg/L drinking water standard in some tubes that monitor a fine-grained unit.

Tritium exceeded the 20,000 pCi/L drinking water standard in a tube in the southern 100-D Area, part of a small plume that originated in the 100-N Area, especially the shallow and mid-depth tubes. New aquifer tubers near the Hanford townsite also exceeded the standard.

Uranium concentrations continued to exceed the 30 µg/L drinking water standard in most of the aquifer tubes in the 300 Area, especially the shallow and mid-depth tubes.

### 1.3.2 Shoreline Seeps

Columbia River seeps (springs) are sampled each autumn by the DOE's Surface Environmental Surveillance Project. Some seeps are sampled to support CERCLA operable unit requirements. Analytical results for seep samples, along with results for adjacent river water, are published in the annual Hanford Site Environmental Report (e.g., PNNL-17603, *Hanford Site Environmental Report for Calendar Year 2007*). Contaminant concentrations typically are much lower in seep water than in groundwater samples from wells and aquifer tubes. In fall 2007, seeps were sampled between September and December.

Chromium concentrations in samples from seeps were below the 100 µg/L drinking water standard for total chromium. Total chromium in filtered samples (equivalent to hexavalent chromium) exceeded the 10 µg/L aquatic standard for hexavalent chromium (WAC 173-201A) in the 100-D, 100-K, and 100-H Areas. The maximum concentration in a filtered sample was 71.9 µg/L in a 100-K Area spring.

The highest strontium-90 concentration in a shoreline seep was 6.2 pCi/L in a 100-H Area seep near a former retention basin. The only flowing 100-N Area seep is located downgradient of the strontium-90 plume there.

Tritium concentrations exceeded the 20,000 pCi/L drinking water standard in one seep from the former Hanford townsite. Results of three samples from the seep ranged from 29,300 to 52,600 pCi/L.

Uranium exceeded the 30 µg/L drinking water standard in 300 Area seeps. The highest concentration was 120 µg/L (total uranium, converted from isotopic data).

## 1.4 Quality Control Highlights

### *H. L. Anastos*

***Evaluation of the groundwater project quality assurance program indicates that the data for FY 2008 are reliable and defensible.***

Groundwater data quality is assessed and enhanced by a multifaceted quality assurance/quality control program. Major components of the program include performance evaluation studies, field quality control samples, blind standards, laboratory quality control samples, and laboratory audits. Overall, evaluation of these components indicates that the majority of the FY 2008 data are reliable and defensible. Specific data values associated with out-of-limits quality control results are flagged in the Hanford Environmental Information System (HEIS) database so that users can be circumspect when using them for interpretation. Appendix C includes details about the quality control program for FY 2008. Highlights for FY 2008 include the following.

- Of the groundwater monitoring data, 94% were considered complete (i.e., not rejected, suspect, associated with a missed holding time, or out-of-limit quality control criteria).
- Transfer of groundwater monitoring analytical services from four offsite contract laboratories to the Waste Sampling and Characterization Facility was completed. The Waste Sampling and Characterization Facility performed 80% of the analytical services for the groundwater project.
- The four laboratories supporting groundwater monitoring participated in several national performance evaluation studies. Overall, the percentage of acceptable results was 98%.
- Field quality control samples include three types of field blanks (full trip, field transfer, and equipment blanks), field duplicates, and split samples. Approximately 96% of field blank, 97% of field duplicate, and 89% of split sample results were acceptable, indicating good precision.
- Recommended holding times were met for 99% of nonradiological sample analysis requests. In general, the missed holding times should not have a significant impact on the data.
- Overall, laboratory performance on blind standards was good; 90% of the results were acceptable.
- Approximately 97% of the laboratory quality control results were within the acceptance limits, indicating that the analyses were in control and reliable data were generated. Specifically, 98% of method blanks, 99% of the laboratory control samples, 96% of the matrix spikes and matrix duplicates, and 99% of the surrogates were within the acceptance limits.
- The DOE and its contractors conducted audits and assessments of the laboratories. Several findings and observations were identified, along with a number of proficiencies. Corrective actions have been accepted for all of the audits.

## 1.5 Related Reports

Other reports and databases relating to Hanford Site groundwater include the following.

- Hanford Environmental Information System database — The main environmental database for the Hanford Site that stores groundwater chemistry data and other environmental data (e.g., soil chemistry, survey data).
- Annual summary reports for interim actions — The annual reports evaluate the performance of pump-and-treat and other remediation systems in the 100 and 200 Areas. Results are summarized in the applicable sections of this report.
- Quarterly RCRA data transmittals — The DOE transmits informal reports quarterly to Ecology after groundwater data have been verified and evaluated (e.g., SGW-37533; SGW-38473; SGW-39325). These reports describe changes or highlights of the quarter with reference to the HEIS database for the analytical results.
- Annual aquifer tube sampling results report (planned publication in FY 2009) — The report discusses chemical and radiological monitoring of aquifer tubes in greater detail than presented in the groundwater annual report.
- PNNL-17603, *Hanford Site Environmental Report for Calendar Year 2007* — The annual report summarizes environmental data, including groundwater, riverbank springs, and river water. It also describes environmental management performance and reports the status of compliance with environmental regulations.
- DOE/RL-2008-46, *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan* (planned publication in FY 2009) — The work plan will contain the planning elements common to all decision units within the 100 Area, and a summary of the remedial investigation/feasibility study tasks. A series of addenda will provide information and planning specific to each of the decision units.
- River Corridor Baseline Risk Assessment — A critical step in developing final remedial action decisions is completion of a quantitative baseline risk assessment. Some of the recent documents associated with this effort include the following.
  - DOE/RL-2007-21, *Risk Assessment for the 100 Area and 300 Area Component of the River Corridor Baseline Risk Assessment* — The risk assessment addresses post-remediation residual contaminant concentrations in the 100 and 300 Areas, as well as the Hanford and White Bluffs townsites.
  - DOE/RL-2005-42, *100 Area and 300 Area Component of the RCBRA Sampling and Analysis Plan* — The plan presents the rationale and approach for sampling and analysis to support risk characterization.
  - WCH-274, *Inter-Areas Component of the River Corridor Baseline Risk Assessment Sampling Summary* — The report describes the 2006 to

Documents relating to Hanford Site groundwater are available on the following websites:

Tri-Party Agreement Administrative Record and Public Information Repository — http://www2.hanford.gov/arpir/

DOE Public Reading Room — http://reading-room.pnl.gov/default.cfm

DOE Information Bridge — http://www.osti.gov/bridge/

Hanford Technical Library — http://libraryweb.pnl.gov/

Hanford Site Groundwater Remediation Project — http://www.hanford.gov/cp/gpp/

River Corridor Baseline Risk Assessment — http://www.washingtonclosure.com/Projects/EndState/baseline_risk_assessment.html

2007 supplemental data collection effort, including sampling locations, samples collected, and any modifications and additions made to the sampling and analysis plan for the 100 and 300 Areas component.

## 1.6 CERCLA Five-Year Review

Whenever contaminants remain in the environment following a remedial action decision, CERCLA regulations require that the regulatory agency conduct a review of the decision at least every five years. The DOE released DOE/RL-2006-20, *The Second CERCLA Five-Year Review Report for the Hanford Site* in November 2006. The purpose of the review was to determine whether the selected remedies are protective of human health and the environment, and recommend appropriate corrective actions if the remedy is not achieving the established goals. The report made the following conclusions regarding groundwater operable units.

- 100-KR-4 and 100-HR-3 Operable Units — Because the groundwater interim actions in the 100 Area are not designed to be remedial actions, the protectiveness of the selected remedies could not be assessed. Contaminants other than the selected principle threat contaminants may be addressed in the interim actions that need to be addressed in the final records of decision.
- 100-NR-2 and 300-FF-5 Operable Units — The interim remedies have not achieved their objectives. Institutional controls are effective in protecting human health. However, determinations of protectiveness are being deferred until a final remedy is selected through the CERCLA remedial investigation/ feasibility study process.
- 100-BC-5 and 100-FR-3 Operable Units — Records of decision for groundwater remediation have not been established for these areas. Previous assessments have not identified groundwater conditions that warrant interim remedial measures, assuming that the source control measures will meet established remedial action objectives designed to reduce contaminant recharge to the aquifer.
- 200-BP-5 and 200-PO-1 Operable Units — Records of decision for groundwater remediation have not been established for these areas.
- 200-ZP-1 Groundwater Operable Unit — Protectiveness determinations for the pump-and-treat and vapor-extraction systems were deferred until a final remedy is selected through the CERCLA remedial investigation/feasibility study process. The final record of decision for this operable unit was approved in September 2008.
- 200-UP-1 Operable Unit — This system has met the remedial action objectives identified in the record of decision for interim action. The need for additional work will be assessed through the CERCLA remedial investigation/feasibility study process.
- 1100-EM-1 Operable Unit — The selected remedial actions have been completed and the remedy remains protective. The operable unit was removed from the National Priorities List (40 CFR 300, Appendix B), and is no longer considered a CERCLA site.

The review identified 20 issues and associated corrective actions that are recommended to ensure selected remedies remain protective of human health and the environment. Actions that pertain to individual groundwater operable units are

discussed in the applicable sections of this report. The three actions pertaining to the River Corridor cut across operable unit boundaries and have all been completed (DOE/RL-2008-01, *Hanford Site Groundwater Monitoring for Fiscal Year 2007*, Table 1.0-4).

## 1.7 EM-22 Technology Proposals

In FY 2006, the U.S. Congress authorized 10 million dollars for "...analyzing contaminant migration to the Columbia River, and for the introduction of new technology approaches to solving contamination migration issues." The DOE's Office of Environmental Management (EM-22) administers these funds. The following studies were underway in FY 2008:

- Inject micron-size iron into the deteriorating portions of the redox barrier (100-HR-3-D)
- Field test electrocoagulation for accelerated cleanup (100-HR-3-D)
- In situ biostimulation of groundwater (100-HR-3-D)
- Chromium vadose zone characterization and geochemistry (100-HR-3-D)
- Location refinement of the chromium source and a geochemical/mineralogical study of chromium in the vadose zone (100-HR-3-D)
- Strontium-90 treatability demonstration of phytoremediation (100-NR-2)
- Sequestration of strontium-90 subsurface contamination by surface infiltration of an apatite solution (100-NR-2)
- Uranium stabilization through polyphosphate injection (300-FF-5)
- Carbon tetrachloride and chloroform attenuation parameter studies (200-ZP-1).

More information on the EM-22 projects is available at http://www.hanford.gov/cp/gpp/science/em21.cfm.

Progress on these projects is summarized in the applicable sections of this report.

## 1.8 Conventions Used in This Report

Well location maps in this report show any well used for sampling or water-level measurements in the past five years. Dry or decommissioned wells are shown with different symbols. On most of the maps well name prefixes (e.g., 199- in the 100 Area, 299- in the 200 Area) are omitted. Aquifer tubes, which are often installed in multi-depth clusters, are usually shown as a single point and depth suffixes (e.g., –S, –M, and –D) are omitted.

Unless specified otherwise, contaminant plume maps in this report are based on average results for samples collected in FY 2008 for each well, excluding data that appear unrepresentative.[1] Averaging data allows the maps to include wells sampled at different times and at different frequencies. In some locations, it is advantageous

1 A table of data excluded from the plume maps, and the rationale for exclusion, is included in the electronic files accompanying this report. The excluded data have been deemed unrepresentative of upper aquifer conditions for reasons such as laboratory error or unusual sampling conditions (e.g., samples collected during drilling or using a method not comparable to routine monitoring).

to construct maps based on data from a single sampling event (e.g., uranium in the 300 Area in June 2008).

Contour levels are chosen to meet of the following objectives:

- Drinking water standards and multiples of 10 (e.g., 8, 80, and 800 pCi/L for strontium-90)
- Cleanup levels, where applicable (e.g., 20 μg/L for chromium)
- Levels lower than drinking water standards to show areas affected by contamination (e.g., 2,000 pCi/L for tritium)
- Intermediate levels to help define plumes (e.g., 60 and 90 μg/L for uranium).

***Most plume maps in this report show average concentrations in the upper part of the aquifer.***

Mapped data are rounded to two significant digits. The maps are interpretations by project staff using current and historical data, source knowledge, and groundwater flow directions. Staff use data from FY 2006 and FY 2007 for wells that did not have new data in FY 2008. Older data and data from aquifer tubes along the Columbia River are given less weight than the current well data when the maps are contoured. The maps show data from wells completed in the upper part of the unconfined aquifer (generally the top ~10 m).

Results less than detection limits (flagged "U" in the HEIS database) are treated in one of two ways when constructing maps.

- For chemical constituents (including total uranium), U-flagged values represent analytical detection limits. These values are treated as zeroes and included in the data to be averaged. If all results (or the only result) for the fiscal year were undetected, a U is plotted on the map. If the data represent a mixture of detected and undetected results, the average is plotted on the map, followed by an asterisk.
- For radiological parameters, if the counting error is greater than the result, the result is flagged U. Other factors also may result in values being flagged U. For plotting on maps, all of the results for the fiscal year are averaged, whether U-flagged or not, because the reported values are statistically significant. The average values are plotted on the map, followed by U (if all results for the fiscal year were undetected) or an asterisk (if the data represent a mixture of detected and undetected values). Note that the laboratories correct results for background radiation. In some cases, background corrected values are negative.

Conventions for handling undetected values do not adversely affect data interpretation for most constituents because the contour intervals are far above detection limits. A notable exception is iodine-129. Iodine-129 is contoured at 1 pCi/L (the drinking water standard), which can be less than the laboratory's detection limit. Historically, samples containing significant concentrations of technetium-99 required pretreatment to remove technetium-99 prior to iodine-129 analysis (PNNL-15070, *Hanford Site Groundwater Monitoring for Fiscal Year 2004*, Section C.6.1). Despite this practice, some values greater than 1 pCi/L were reported as undetected. Currently, the laboratory can process technetium-99 containing samples without the pretreatment, while maintaining the minimum detectable activity at 1 pCi/L. However, the laboratory still requires that both primary and secondary energy peaks are present before considering iodine-129 detected. Requiring the secondary (less sensitive) energy peak adds conservatism to the laboratory's report (i.e., the laboratory only reports a detection when certain of the detection). Many

of the U-flagged values are believed to be real detections, and they are contoured as such. The contour lines are dashed to show that the distribution of iodine-129 at levels near the drinking water standard is less certain than other contaminants.

Trend plots may omit results that appear to be erroneous if they distort or obscure the scale and data trends. The figures note the omission. All of the data, with appropriate data quality flags, are included in the data files accompanying this report and are available in the HEIS database. Trend plots in this report use open symbols to show values so low the laboratory could not detect them. These results are typically reported and plotted as values that represent the detection limit for chemical parameters, and reported values for radiological parameters. Discussion of increasing or decreasing trends generally are based on qualitative observation, not statistical evaluation.

When groundwater samples are collected for metals analysis, two samples are routinely collected: one filtered in the field and the other unfiltered. Collection of unfiltered samples for metals analysis began in FY 2008 in response to a letter from EPA and Ecology (Hedges and Ceto, 2007, "Field-Filtering of Ground Water Samples Prior to Laboratory Analysis"). Previously, only filtered metals samples were collected from most wells. Unfiltered samples, especially from turbid samples, may contain particulate material from the well screen or aquifer that affects concentrations of some metals. EPA and Ecology were concerned that the use of field-filtered samples might cause an underestimation of the amount of contamination that is naturally mobile in groundwater. Collecting both filtered and unfiltered samples will provide data with which to compare dissolved trace metals concentrations (filtered samples) to total trace metals concentrations (unfiltered samples). In this report, both filtered and unfiltered results are provided in discussions of metals. Other samples, including non-metals, hexavalent chromium, and uranium, generally are not filtered in the field unless the sample turbidity is excessive.

This report uses the following conventions for chemical results.

- Text, figures, and tables express nitrate and nitrite as the $NO_3^-$ and $NO_2^-$ ions, respectively.
- Maps showing chromium include total chromium in filtered samples and hexavalent chromium in filtered or unfiltered samples. Dissolved chromium in Hanford Site groundwater is virtually all hexavalent (WHC-SD-EN-TI-302, *Speciation and Transport Characteristics of Chromium in the 100D/H Areas of the Hanford Site*), so filtered, total chromium data effectively represent hexavalent chromium. DOE/RL-2008-01, Appendix C compares chromium data from filtered, unfiltered, total, and hexavalent analyses.
- Contaminant concentrations are compared with state or federally enforceable drinking water standards (Table 1.0-5). Although Hanford Site groundwater is not generally used for drinking, these levels provide perspective on contaminant concentrations. Radionuclide concentrations also are compared with DOE derived concentration guides and risk-based concentrations based on cancer risk coefficients (Table 1.0-6).

***Dissolved chromium in Hanford Site groundwater is virtually all hexavalent.***

***For additional information on contaminants that are found at the Hanford Site, see Peterson et al., 2007, Radiological and Chemical Fact Sheets to Support Health Risk Analyses for Contaminated Areas, available on the web site of Environmental Assessment Division, Argonne National Laboratory (http://www.ead.anl.gov/pub).***

**Table 1.0-1. Reporting Requirements for Groundwater Monitoring.**

| Operable Unit or Facility | Formal Report | Supplemental Reports or Summaries |
|---|---|---|
| **CERCLA** | | |
| Operable units without RODs (100-BC-5, 100-FR-3, 200-BP-5, 200-PO-1) | This report | Unit manager's meeting presentations |
| Operable units with interim action RODs (100-KR-4, 100-NR-2, 100-HR-3, 200-UP-1, 200-ZP-1) | Interim action annual reports (summarized in this report) | Unit manager's meeting presentations; this report |
| Operable unit with interim action ROD (300-FF-5) | This report | Unit manager's meeting presentations; this report |
| Operable unit with final ROD (1100-EM-1) | This report | None |
| ERDF | Separate annual report covers groundwater and leachate (summarized in this report) | This report |
| **RCRA Units** | | |
| Operating RCRA units (IDF, LERF, LLBG) | This report | Informal quarterly reports |
| Closure RCRA units (116-N-1 and -3; 120-N-1 and -2) | This report | Informal quarterly reports |
| Post-closure RCRA units (116-H-6 and 316-5) | Semiannual reports to Ecology; this report | Informal quarterly reports |
| Interim-status assessment RCRA sites (PUREX Cribs, WMA A-AX, B-BX-BY, S-SX, T, TX-TY, and U) | This report; also occasional assessment reports | Informal quarterly reports |
| Interim-status detection (216-A-29, 216-B-63, 216-S-10 Pond, NRDWL, and WMA C) | This report | Informal quarterly reports |
| **Other Facilities** | | |
| AEA sites (K Basins, 400 Area water supply wells) | This report | Unit manager's meeting presentation |
| SALDS (WAC 173-216) | Separate annual report | This report |
| TEDF (WAC 173-216) | This report | None |
| SWL (WAC 173-304) | This report for groundwater; separate report for leachate and soil gas | None |

AEA = *Atomic Energy Act of 1954.*
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*
Ecology = Washington State Department of Ecology.
ERDF = Environmental Restoration Disposal Facility.
IDF = Integrated Disposal Facility (planned).
LERF = Liquid Effluent Retention Facility.
LLBG = low-level burial grounds.
NRDWL = Nonradioactive Dangerous Waste Landfill.
PUREX = Plutonium-Uranium Extraction Plant.
RCRA = *Resource Conservation and Recovery Act of 1976.*
ROD = record of decision.
SALDS = State-Approved Land Disposal Site.
SWL = Solid Waste Landfill.
TEDF = Treated Effluent Disposal Facility.
WAC = *Washington Administrative Code.*
WMA = waste management area.

**Table 1.0-2. Fiscal Year 2008 RCRA Monitoring Status.**

| RCRA Unit | Report Section | FY 2008 Status |
|---|---|---|
| 116-N-1 (1301-N) Facility | 2.4.3.1 | Continued detection* |
| 120-N-1, (1324-NA) 120-N-2 (1324-N) Facilities | 2.4.3.2 | Continued detection;* one new well completed early FY 2009 to replace seasonally dry well. |
| 116-N-3 (1325-N) facility | 2.4.3.3 | Continued detection* |
| 116-H-6 (183-H) Evaporation Basins | 2.6.3 | Corrective action alternative program during interim remedial action. Chromium, nitrate. |
| 216-A-29 Ditch | 2.11.3.4 | Continued detection* |
| 216-B-3 Pond | 2.11.3.5 | Continued detection* |
| 216-B-63 Trench | 2.10.3.2 | Continued detection* |
| 216-S-10 Pond and Ditch | 2.9.3.3 | Continued detection;* three new wells. |
| 316-5 (300 Area) Process Trenches | 2.12.3 | Compliance/corrective action; organics. |
| Integrated Disposal Facility | 2.11.3.1 | Not yet in use; monitoring results added to background data set. |
| LERF | 2.10.3.5 | Two new wells monitor fractured basalt flow-top. DOE and Ecology pursuing agreement for monitoring. |
| LLWMA 1 | 2.10.3.3 | Continued detection* |
| LLWMA 2 | 2.10.3.4 | Continued detection* |
| LLWMA 3 | 2.8.3.1 | Statistical evaluations suspended until upgradient wells installed and background values established. |
| LLWMA 4 | 2.8.3.2 | TOC exceeded critical mean value in August 2008; beginning assessment FY 2009; remaining upgradient wells went dry. |
| NRDWL | 2.11.3.6 | TOC exceeded critical mean value in August 2008; beginning assessment FY 2009. |
| PUREX Cribs | 2.11.3.2 | Continued assessment: nitrate. |
| SST WMA A-AX | 2.11.3.3 | Continued assessment (first determination); new well. |
| SST WMA B-BX-BY | 2.10.3.1 | Continued assessment: nitrate. |
| SST WMA C | 2.10.3.6 | Continued detection* |
| SST WMA S-SX | 2.9.3.2 | Continued assessment: chromium, nitrate. |
| SST WMA T | 2.8.3.3 | Continued assessment: chromium, nitrate. |
| SST WMA TX-TY | 2.8.3.4 | Continued assessment: chromium, nitrate. |
| SST WMA U | 2.9.3.1 | Continued assessment: nitrate. |

* Analysis of RCRA contamination indicator parameters provided no evidence of groundwater contamination with hazardous constituents from the unit.

FY = fiscal year.
LERF = Liquid Effluent Retention Facility.
LLWMA = Low Level Waste Management Area.
NRDWL = Nonradioactive Dangerous Waste Landfill.
PUREX = Plutonium-Uranium Extraction Plant.
RCRA = *Resource Conservation and Recovery Act of 1976.*
SST = single-shell tanks.
TOC = total organic carbon.
WMA = Waste Management Area.

**Table 1.0-3. Number of Groundwater Analyses, Fiscal Year 2008.**

| Constituent | Site Total |
|---|---|
| Chromium (total and hexavalent) | 3,968 |
| Gross alpha | 933 |
| Gross beta | 1,139 |
| Iodine-129 | 485 |
| Nitrate | 2,146 |
| Organics (carbon tetrachloride, trichloroethene) | 835 |
| Plutonium-239/240 | 49 |
| Strontium-90 | 557 |
| Technetium-99 | 1,068 |
| Tritium | 1,409 |
| Uranium | 994 |

## Table 1.0-4. Maximum Concentrations of Selected Groundwater Contaminants in Groundwater Interest Areas, Fiscal Year 2008.

| Contaminant, units (alphabetical order) | DWS (DCG)[a] | 100-BC-5 | | 100-KR-4 | | 100-NR-2 | | 100-HR-3-D | | 100-HR-3-H | | 100-FR-3 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Wells | Aquifer Tubes | Wells | Aquifer Tubes | Wells | Aquifer Tubes | Wells | Aquifer Tubes | Wells | Aquifer Tubes | Wells | Aquifer Tubes |
| Arsenic[b] (filtered) (µg/L) | 10 | | | | 2.59 | | | 4.87 | 0.761 | | | | |
| Arsenic[b] (µg/L) | 10 | | | 8.04 | 2.85 | | | 5 | 0.678 | | | | |
| Carbon tetrachloride (µg/L) | 5 | | | | | | | | | | | | |
| Carbon-14 (pCi/L) | 2,000 (70,000) | | | **6,740** | 349 | 10.7 | | | | | | | |
| Cesium-137 (Ci/L) | 200 (3,000) | | | | | | | | | | | | |
| Chloroform (µg/L) | 100 | | | 0.4 | | 0.91 | | | | | | | |
| Chromium,[b] total (filtered) (µg/L) | 100 | 50.5 | | **3,350** | 79.7 | **172** | 13.2 | **10,500** | **364** | **100** | | 42.5 | 11.7 |
| Chromium,[b] total (µg/L) | 100 | 52.5 | | **3,550** | 72.4 | **493** | 15.7 | **9,970** | **362** | 93.8 | | 51.8 | 17.3 |
| Chromium,[b] hexavalent (filtered) (µg/L) | 100 | | | | | | | **296** | | | | | |
| Chromium,[b] hexavalent (µg/L) | 100 | 54.8 | 46.3 | **3,540** | 80.9 | 87 | 64.9[c] | **39,900** | **422** | **157** | 73.7 | 10.9 | 11.9 |
| cis-1,2-Dichloroethylene (µg/L) | 70 | | | | | | | | | | | | |
| Cobalt-60 (pCi/L) | 100 (5,000) | | | | | | | | | | | | |
| Cyanide (µg/L) | 200 | | | | | | | | | | | | |
| Fluoride (mg/L) | 4 | 0.23 | 0.181 | 0.44 | 0.303 | 0.686 | 0.434 | 0.508 | 0.191 | 0.5 | 0.182 | 0.681 | 0.21 |
| Gross alpha (pCi/L) | 15 | 1.57 | 2.4 | **24.1** | 2.58 | 5.7 | 4.6 | 3.34 | | 4.3 | 3.67 | 12 | 2.9 |
| Gross beta (pCi/L) | 50 | **87** | 40 | **3,000** | 6.96 | **51,000**[d] | **150,000**[d] | **152** | 15 | **57.2** | 24.3 | **51.2** | 6.2 |
| Iodine-129 (pCi/L) | 1 (500) | | | | | | | | | | | | |
| Nitrate (mg/L) | 45 | 39.5 | 22.3 | **139** | **52.7** | **259** | **54** | **116** | 35.4 | 44.3 | **45.6** | **114** | 40.9 |
| Nitrite (mg/L) | 3.3 | 0.414 | | 0.371 | 0.053 | 0.805 | 0.079 | **5.42** | | 0.453 | 0.049 | | 0.039 |
| Plutonium-239/240 (pCi/L) | 1.2[e] (30) | | | | | | | | | | | | |
| Strontium-90 (pCi/L) | 8 (1,000) | **44.7** | **16** | ***1,610*** | 3.3 | ***17,000*** | ***75,000***[d] | 7.7 | 2.56 | **24.8** | **11.6** | **25.8** | 4.4 |
| Technetium-99 (pCi/L) | 900 (100,000) | 11.4 | 45.4 | 63 | | | | 87 | | 31 | | | |
| Tetrachloroethene (µg/L) | 5 | | | | | | | | | | | | |
| Trichloroethene (µg/L) | 5 | | | **7.7** | | | | | | | | **9.7** | |
| Tritium (pCi/L) | 20,000 (2,000,000) | **57,000** | 20,000 | **621,000** | 8,300 | **22,000** | 12,000 | **27,000** | **23,000** | 5,500 | | 15,000 | 920 |
| Uranium (µg/L) | 30 | | | 6.93 | | | | 3.89 | | 8.38 | 2.32 | 17.6 | |

## Table 1.0-4. (cont.)

| Contaminant, units (alphabetical order) | DWS (DCG)[a] | 200-ZP-1 | 200-UP-1 | 200-BP-5 | | 200-PO-1 | | 300-FF-5 | | 1100-EM-1 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Wells | Wells | Wells | Aquifer Tubes | Wells | Aquifer Tubes | Wells | Aquifer Tubes | Wells |
| Arsenic[b] (filtered) (µg/L) | 10 | **10.8** | 6.19 | **17.4** | | **10.2** | | | 3.07 | |
| Arsenic[b] (µg/L) | 10 | **14.2** | 5.8 | **23.4** | | **10.5** | | | 2.56 | |
| Carbon tetrachloride (µg/L) | 5 | **4,900** | **1,400** | 3.4 | | 1 | | 3.5 | 1.4 | 2.9 |
| Carbon-14 (pCi/L) | 2,000 (70,000) | | 32.9 | 141 | | | | | | |
| Cesium-137 (Ci/L) | 200 (3,000) | | | **1,650** | | | | | | |
| Chloroform (µg/L) | 100 | 32 | 17 | 0.52 | | 0.3 | | 2.1 | 2.8 | |
| Chromium,[b] total (filtered) (µg/L) | **100** | **640** | **823** | **233** | | 47.1 | 3.2 | 90.7 | 7 | 6.6 |
| Chromium,[b] total (µg/L) | **100** | **670** | **846** | **140** | 8.1 | 71.2 | 3.3 | 86.3 | 12.9 | 16.5 |
| Chromium,[b] hexavalent (filtered) (µg/L) | 100 | | | | | | | | | |
| Chromium,[b] hexavalent (µg/L) | 100 | 50 | 61 | 43.2 | 16 | | 3.7 | | | |
| cis-1,2-Dichloroethylene (µg/L) | 70 | | | | | | | **190** | 4.8 | |
| Cobalt-60 (pCi/L) | 100 (5,000) | | | **1,040**[f] | | | | | | |
| Cyanide (µg/L) | 200 | | 4.1 | **7,180**[f] | | | | | | |
| Fluoride (mg/L) | 4 | **4.56** | 0.55 | **107** | 0.316 | **9.09** | 0.16 | **16.7** | 0.717 | 1.24 |
| Gross alpha (pCi/L) | 15 | 8.3 | 8.27 | **1,800** | 1.93 | **30** | 5.03 | **110** | **54** | 7.6 |
| Gross beta (pCi/L) | 50 | **5,200** | **10,400** | **34,000** | 40.6 | **4,400** | 6.32 | **160** | **53** | 9.4 |
| Iodine-129 (pCi/L) | 1 (500) | **37.6** | **37.1** | **5.63** | | **10.4** | | | | |
| Nitrate (mg/L) | 45 | **2,820** | **868** | **17,800**[f] | 28.4 | **127** | 33 | **293** | **52.2**[g] | **307**[g] |
| Nitrite (mg/L) | 3.3 | 0.907 | 0.545 | **18.6** | | 0.552 | | 0.69 | 0.161 | |
| Plutonium-239/240 (pCi/L) | 1.2 • (30) | 0.021 | | **27** | | | | | | |
| Strontium-90 (pCi/L) | 8 (1,000) | 3.8 | 2.8 | ***3,740*** | | **20.2** | 1.9 | | | |
| Technetium-99 (pCi/L) | 900 (100,000) | **18,000** | **67,000** | **100,000**[f] | 114 | **8,000** | | 225 | | |
| Tetrachloroethene (µg/L) | 5 | 2.1 | | | | 2.6 | | | 4.7 | |
| Trichloroethene (µg/L) | 5 | **11** | **9.6** | | | 1.7 | | 4.2 | **530** | |
| Tritium (pCi/L) | 20,000 (2,000,000) | **1,200,000** | **290,000** | **170,000**[f] | 13,000 | **650,000** | **35,000** | **940,000** | 9,100 | 1,500 |
| Uranium (µg/L) | 30 | **48.8** | **391** | **3,910** | | 30 | | **225** | **180** | 26.5 |

Note: Table lists highest value for fiscal year 2008 in each groundwater interest area, excluding those flagged "R" or "Y" or special (non-routine) samples (except as noted).
Concentrations in bold exceed DWS. Those in bold italics exceed DCG.
Blank cells indicate a constituent was not detected or not analyzed.

[a] DWS = drinking water standard; DCG = derived concentration guide. See Table 1.0-5 and 1.0-6 for more information.

[b] Most metals analyses are run both unfiltered and field-filtered samples. Higher concentrations in unfiltered samples indicate particulate matter in the sample. Note that analyses specifically for hexavalent chromium usually are not filtered in the field.

[c] Value from aquifer tube on boundary of 100-KR-4 groundwater interest area. 100-N Area aquifer tubes have lower chromium.

[d] Results from special sampling for apatite treatability test. Strontium-90 value was calculated as one-half the maximum gross beta value.

[e] There is no DWS for plutonium-239/240. The 4 mrem/yr effective dose equivalent is 1.2 pCi/L.

[f] Sample from well 299-E33-4, which is nearly dry.

[g] Nitrate from offsite sources.

**Table 1.0-5. Selected Drinking Water Standards and Groundwater Cleanup Levels.**

| Constituent | DWS | Agency[a] | MTCA[b] |
|---|---|---|---|
| Aluminum (µg/L) | 50 to 200[c] | EPA | 16,000 |
| Antimony (µg/L) | 6 | EPA, DOH | 6.4 |
| Arsenic (µg/L) | 10 | EPA, DOH | 0.058 |
| Barium (µg/L) | 2,000 | EPA, DOH | 3,200 |
| Cadmium (µg/L) | 5 | EPA, DOH | 8.0 |
| Carbon tetrachloride (µg/L) | 5 | EPA, DOH | 0.337 |
| Chloride (mg/L) | 250[c] | EPA, DOH | |
| Chloroform (THM)[d] (µg/L) | 70 | EPA, DOH | 7.17 |
| Chromium (µg/L) | 100[e] | EPA, DOH | 48[f] |
| cis-1,2-Dichloroethene (µg/L) | 70 | EPA, DOH | 80 |
| Copper (µg/L) | 1,300[g] | EPA, DOH | 640 |
| | 1,000[c] | EPA | |
| Cyanide (µg/L) | 200 | EPA, DOH | 0.104 |
| Fluoride (mg/L) | 4 | EPA, DOH | 0.960 |
| | 2[c] | EPA, DOH | |
| Iron (µg/L) | 300[c] | EPA, DOH | 11,200 |
| Lead (µg/L) | 15[g] | EPA, DOH | |
| Manganese (µg/L) | 50[c] | EPA, DOH | 752 |
| Mercury (inorganic) (µg/L) | 2 | EPA, DOH | 4.8 |
| Methylene chloride (Dichloromethane) (µg/L) | 5 | EPA | 5.83 |
| Nitrate, as $NO_3^-$ (mg/L) | 45[h] | EPA, DOH | 115 |
| Nitrite, as $NO_2^-$ (mg/L) | 3.3[i] | EPA, DOH | 5.3 |
| pH | 6.5 to 8.5[c] | EPA | |
| Selenium (µg/L) | 50 | EPA, DOH | 80 |
| Silver (µg/L) | 100[c] | EPA, DOH | 80 |
| Sulfate (mg/L) | 250[c] | EPA, DOH | |
| Tetrachloroethene (µg/L) | 5 | EPA, DOH | 80 |
| Thallium (µg/L) | 2 | EPA, DOH | 1.12 |
| Total dissolved solids (mg/L) | 500[c] | EPA, DOH | |
| 1,1,1-Trichloroethane (µg/L) | 200 | EPA, DOH | 16,000 |
| Trichloroethene (µg/L) | 5 | EPA, DOH | 0.49 |
| Zinc (µg/L) | 5,000[c] | EPA, DOH | 4,800 |
| Antimony-125 (pCi/L) | 300[j] | EPA | |
| Beta particle and photon activity (mrem/yr) | 4[k] | EPA, DOH | |
| Carbon-14 (pCi/L) | 2,000[j] | EPA | |
| Cesium-137 (pCi/L) | 200[j] | EPA | |
| Cobalt-60 (pCi/L) | 100 pCi/L[j] | EPA | |
| Iodine-129 (pCi/L) | 1 pCi/L[j] | EPA | |
| Ruthenium-106 (pCi/L) | 30 pCi/L[j] | EPA | |
| Strontium-90 (pCi/L) | 8 pCi/L[j] | EPA, DOH | |
| Technetium-99 (pCi/L) | 900 pCi/L[j] | EPA | |

**Table 1.0-5. (cont.)**

| Constituent | DWS | Agency[a] | MTCA[b] |
|---|---|---|---|
| Total alpha (excluding uranium) (pCi/L) | 15[j] | EPA, DOH | |
| Tritium (pCi/L) | 20,000[j] | EPA, DOH | |
| Uranium (µg/L) | 30 | EPA, DOH | 48 |

[a] DOH = Washington State Department of Health at WAC 246-290; EPA = U.S. Environmental Protection Agency at 40 CFR 141, 40 CFR 143, and EPA/822/R-96/001.
[b] Model Toxics Control Act, Method B cleanup levels for groundwater (WAC 173-340).
[c] Secondary standards are not associated with health effects, but with taste, odor, staining, or other aesthetic qualities.
[d] Standard is for total trihalomethanes.
[e] Total chromium.
[f] Hexavalent chromium.
[g] Action level.
[h] 45 mg/L as $NO_3$- is equivalent to 10 mg/L as N.
[i] 3.3 mg/L as $NO_2$- is equivalent to 1 mg/L as N.
[j] EPA drinking water standards for radionuclides were derived based on a 4-mrem/yr dose standard using maximum permissible concentrations in water specified in NBS Handbook 69 (U.S. Department of Commerce, as amended August 1963).
[k] Beta and gamma radioactivity from anthropogenic radionuclides. Annual average concentration shall not produce an annual dose from anthropogenic radionuclides equivalent to the total body or any internal organ dose >4 mrem/yr. If two or more radionuclides are present, the sum of their annual dose equivalents shall not exceed 4 mrem/yr. Compliance may be assumed if annual average concentrations of total beta, tritium, and strontium-90 are <50, 20,000, and 8 pCi/L, respectively.

DWS = drinking water standard (maximum contaminant level for drinking water supplies).

**Table 1.0-6. Derived Concentration Guides, 4 mrem Effective Dose Equivalent Concentrations, for Drinking Water Standards, and Risk-based Concentrations for Hanford Site Radionuclides in Groundwater.**

| Radionuclide | Derived Concentration Guide [a,b,c] (pCi/L) | 4-mrem Effective Dose Equivalent [d] (pCi/L) | Drinking Water Standard (pCi/L) | Risk-Based Concentration [e] (pCi/L) Industrial | Risk-Based Concentration (pCi/L) Residential |
|---|---|---|---|---|---|
| Carbon-14 | 70,000 | 2,800 | 2,000 | 1,030 | 34 |
| Cesium-137 | 3,000 | 120 | 200 | 60 | 1.7 |
| Cobalt-60 | 5,000 | 200 | 100 | 102 | 3.4 |
| Iodine-129 | 500 | 20 | 1 | 11 | 0.36 |
| Plutonium-239/240 | 30 | 1.2 | None | 12 | 0.39 |
| Strontium-90 | 1,000 | 40 | 8 | 29 | 0.95 |
| Technetium-99 | 100,000 | 4,000 | 900 | 580 | 19 |
| Tritium | 2,000,000 | 80,000 | 20,000 | 2,600 | 160 |
| Uranium-234 [f] | 500 | 20 | None | 23 | 0.75 |
| Uranium-235 [f] | 600 | 24 | None | 23 | 0.76 |
| Uranium-238 [f] | 600 | 24 | None | 25 | 0.83 |

[a] Concentration of a specific radionuclide in water that could be continuously consumed at average annual rates and not exceed an effective dose equivalent of 100 mrem/yr.
[b] Values in this column represent the lowest, most conservative derived concentration guides considered potentially applicable to Hanford Site operations, and may be adjusted upward (larger) if accurate solubility information is available.
[c] From DOE O 5400.5.
[d] Concentration of a specific radionuclide in water that would produce an effective dose equivalent of 4 mrem/year if consumed at average annual rates. EPA drinking water standards for radionuclides listed in Table 1.1-5 were derived based on a 4-mrem/year dose standard using maximum permissible concentrations in water specified in National Bureau of Standards Handbook 69 (U.S. Department of Commerce, as amended August 1963). The 4-mrem/yr dose standard listed in this table was calculated using a more recent dosimetry system adopted by DOE and other regulatory agencies (as implemented in DOE O 5400.5 in 1993).
[e] Based on slope factors from EPA's risk website: "Radionuclide Carcinogenicity Slope Factors," http://epa.gov/radiation/heast/index.html, in turn based on FGR-13 (EPA/402/R-99/001). These slope factors represent the risk of getting cancer if a person ingested water contaminated with each radionuclide over a lifetime (residential) or over a working lifetime (industrial). The tritium calculation also considers inhalation of tritium in air; for the other radionuclides this path is insignificant.
[f] See Table 1.1-5 for total uranium.

DOE = U.S. Department of Energy.
EPA = U.S. Environmental Protection Agency.

**Figure 1.0-1. Groundwater Operable Units and Groundwater Interest Areas on the Hanford Site.**

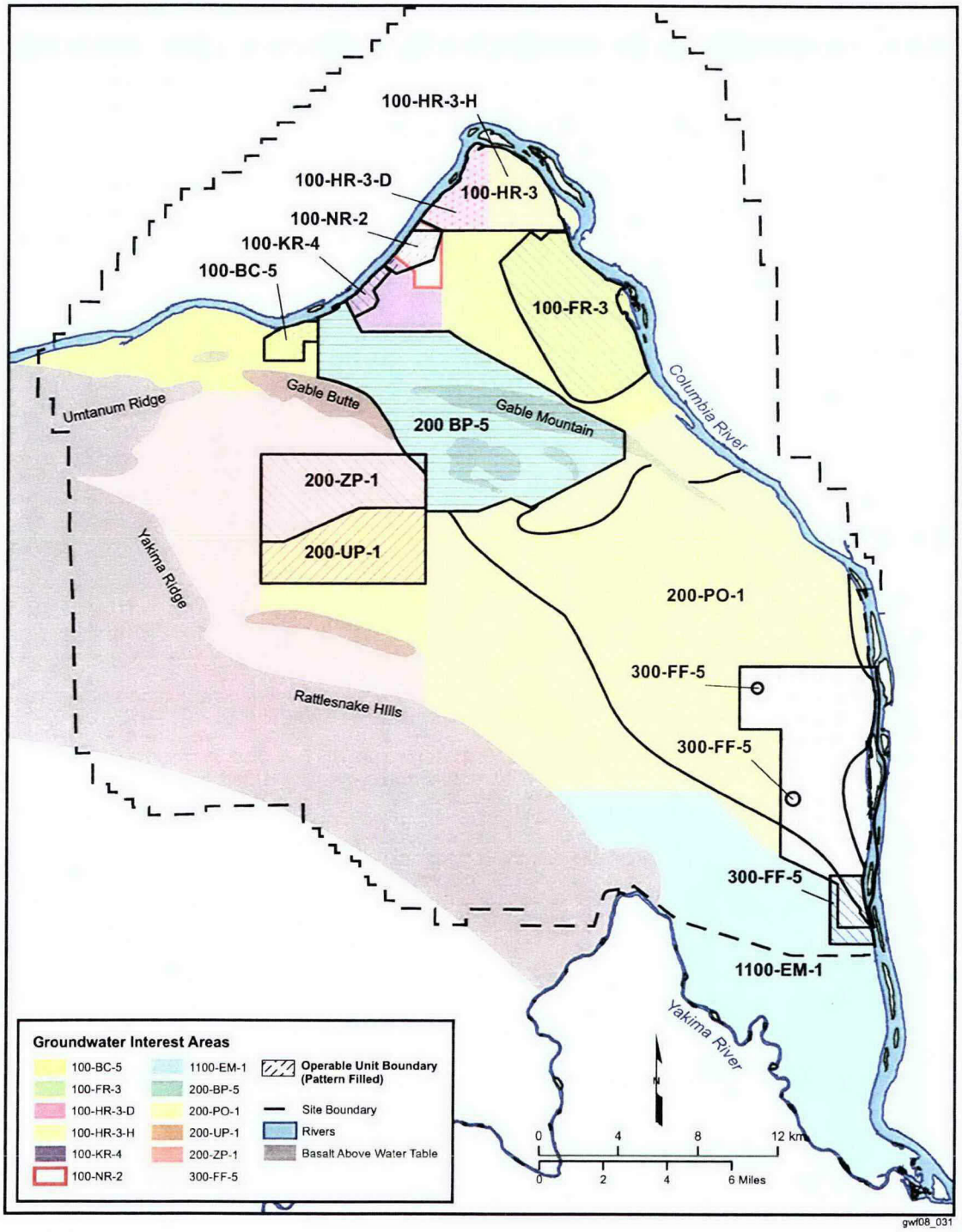


**Figure 1.0-2. Average FY 2008 Tritium Concentrations on the Hanford Site, Upper Part of Unconfined Aquifer.**

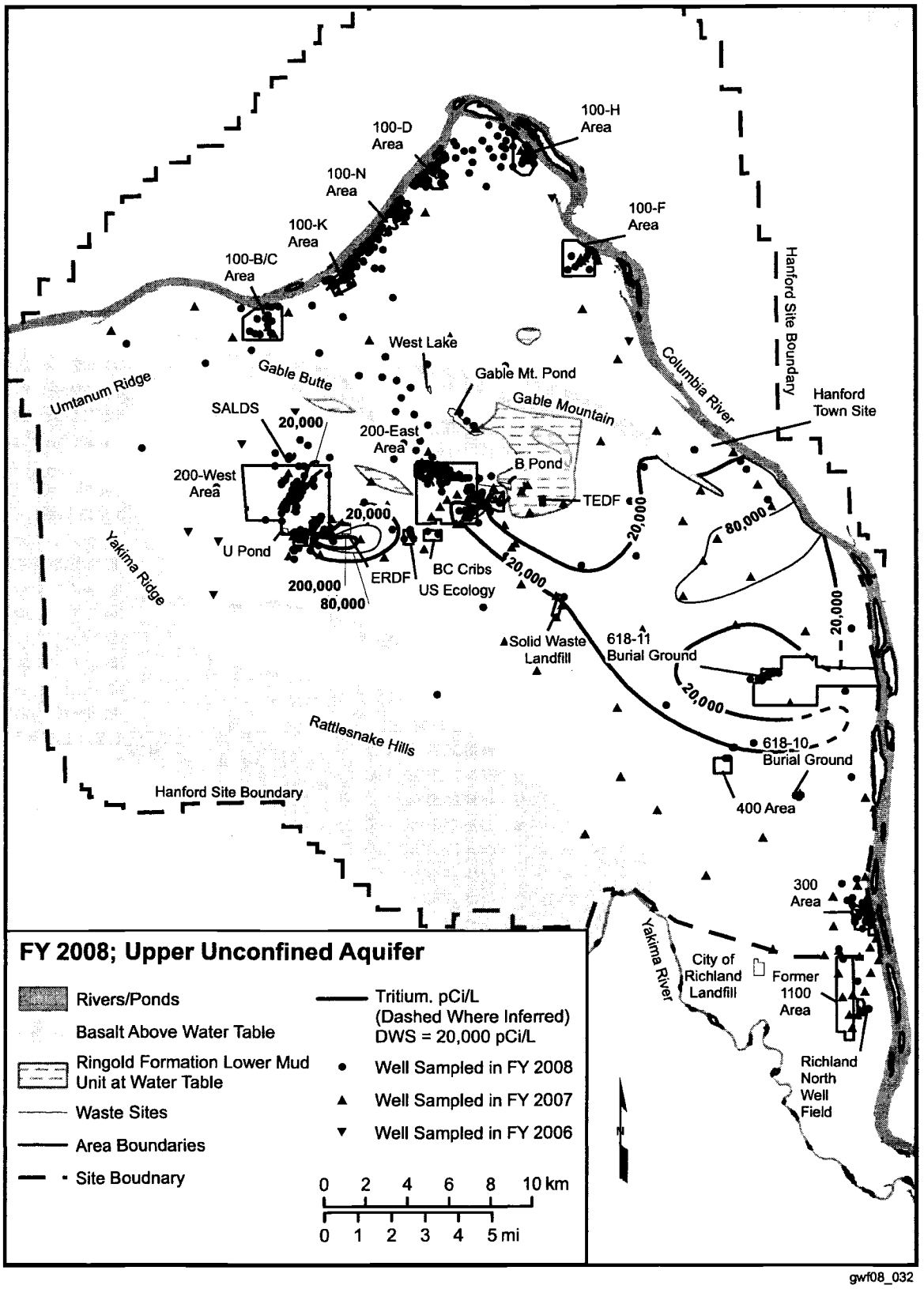


**Figure 1.0-3. Average FY 2008 Nitrate Concentrations on the Hanford Site, Upper Part of Unconfined Aquifer.**

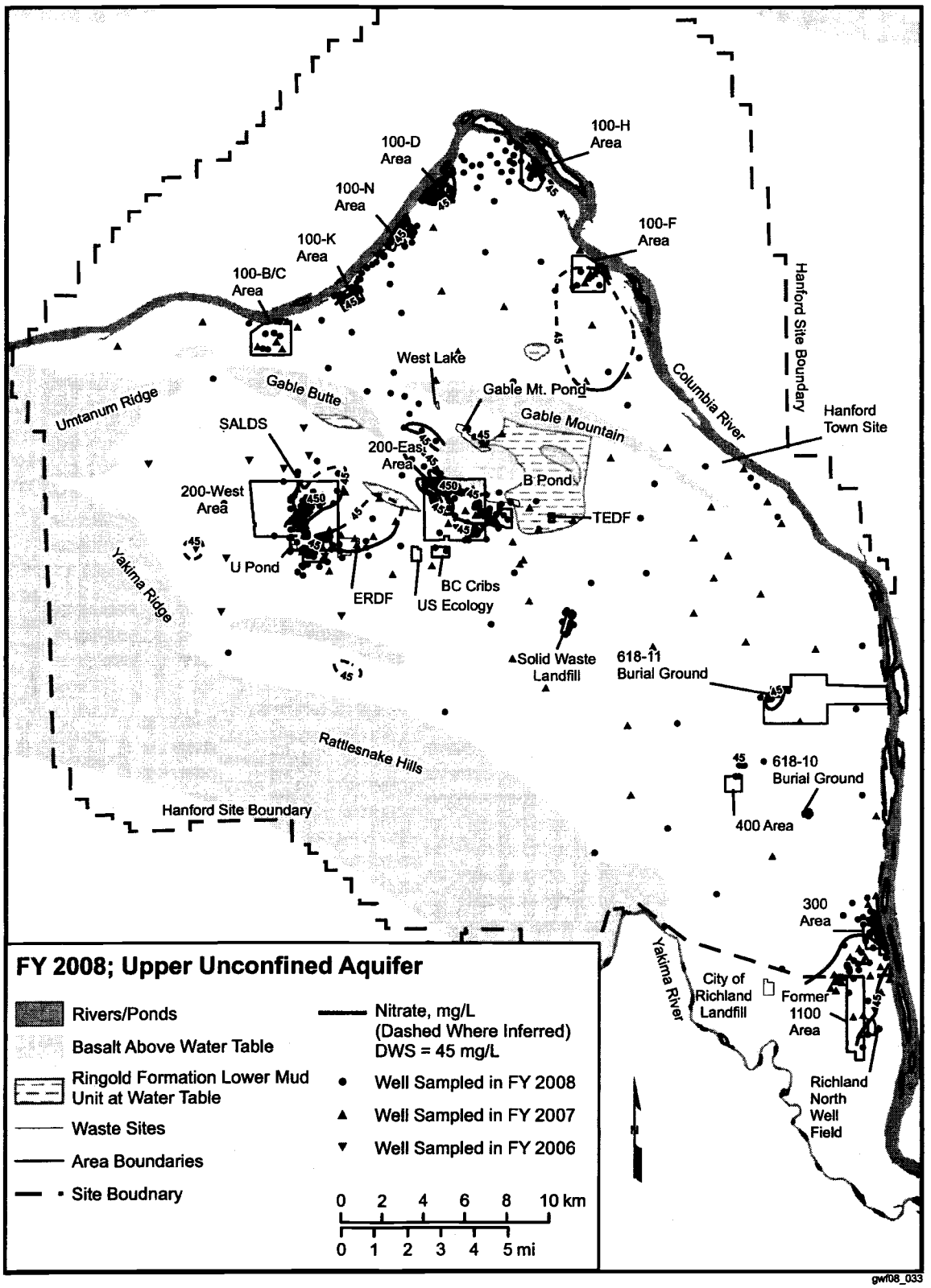


**Figure 1.0-4. Average FY 2008 Iodine-129 Concentrations on the Hanford Site, Upper Part of Unconfined Aquifer.**

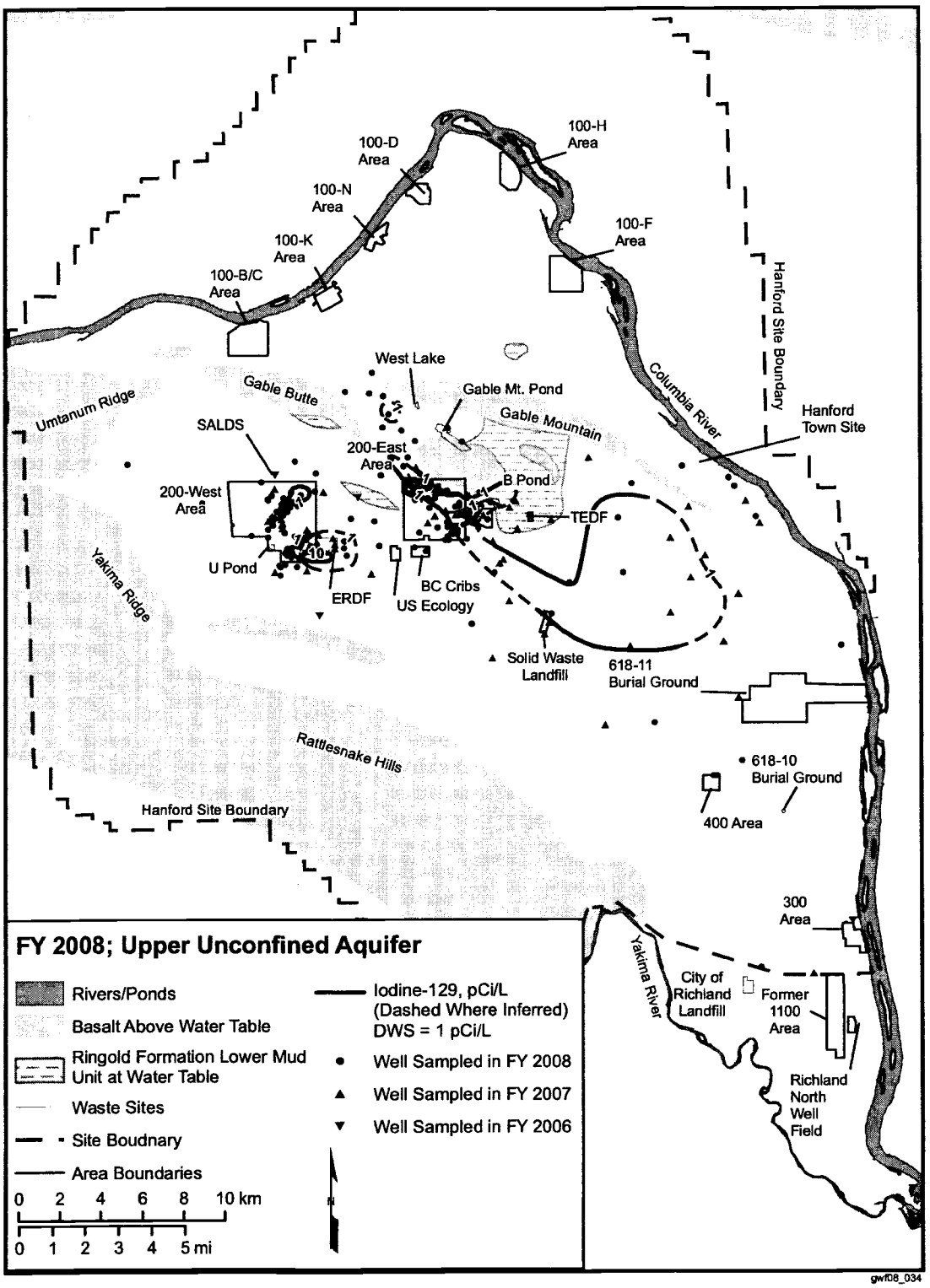
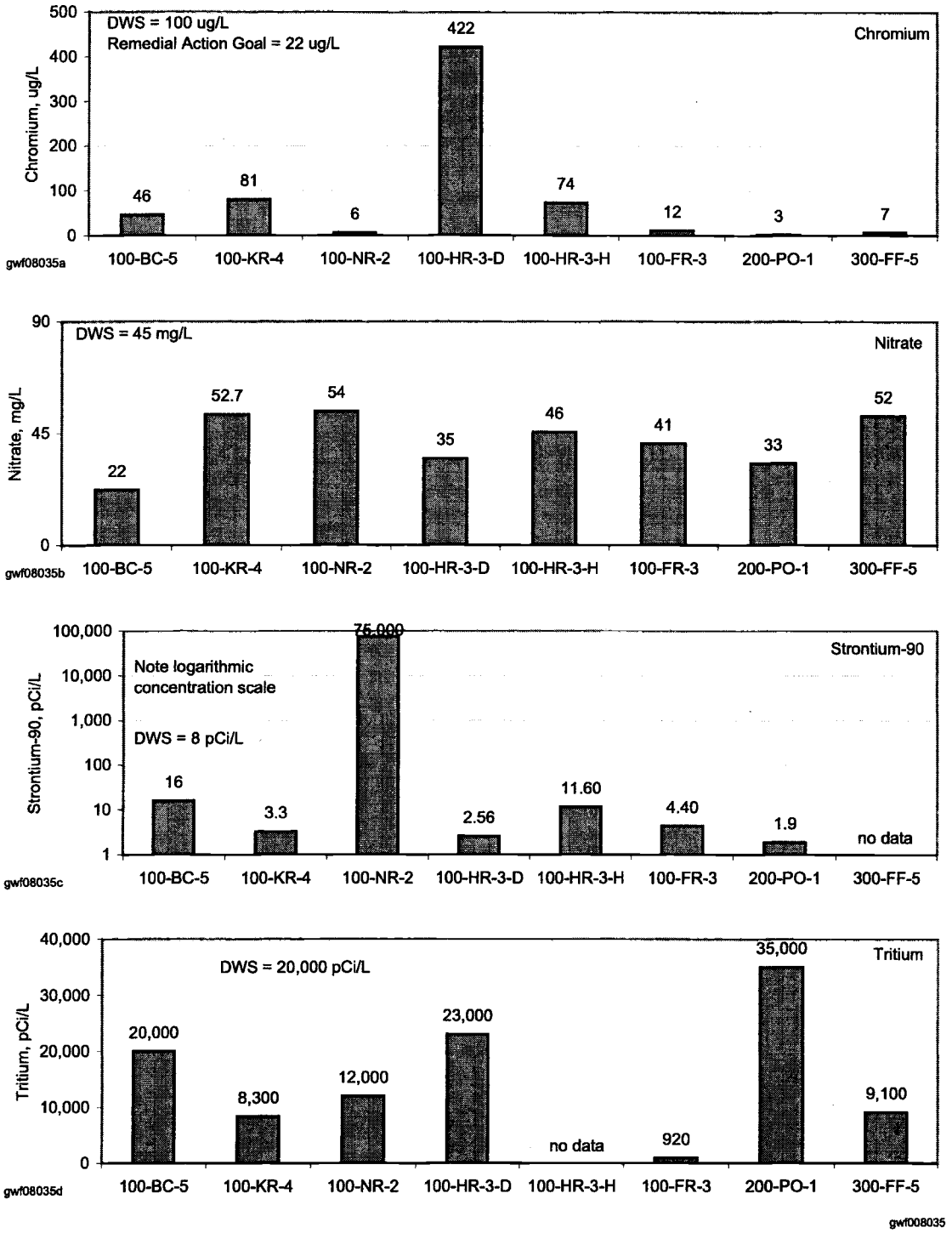


**Figure 1.0-5. Maximum Concentrations of Four Contaminants in Aquifer Tubes in Each Groundwater Interest Area, FY 2008.**



# 2.0 Groundwater

***M. J. Hartman***

This chapter discusses groundwater flow and chemistry on the Hanford Site. Section 2.1 gives a general overview of site-wide groundwater flow. Sections 2.2 through 2.13 describe groundwater flow and chemistry for various regions of the Hanford Site. These regions are based on groundwater operable units. However, the groundwater operable units do not cover the entire Hanford Site. To provide scheduling, data review, and interpretation for the entire site, groundwater staff have defined informal "groundwater interest areas" that include the groundwater operable units and intervening regions. These regions are presented in geographic order (north to south, west to east). Section 2.14 describes groundwater flow and chemistry in the confined aquifers.

- Section 2.1, Groundwater Flow
- Section 2.2, 100-BC-5 Operable Unit (100-B/C Area)
- Section 2.3, 100-KR-4 Operable Unit (100-K Area)
- Section 2.4, 100-NR-2 Operable Unit (100-N Area)
- Section 2.5, 100-HR-3-D Groundwater Interest Area (100-D Area)
- Section 2.6, 100-HR-3-H Groundwater Interest Area (100-H Area)
- Section 2.7, 100-FR-3 Operable Unit (100-F Area)
- Section 2.8, 200-ZP-1 Operable Unit (northern 200 West Area)
- Section 2.9, 200-UP-1 Operable Unit (southern 200 West Area)
- Section 2.10, 200-BP-5 Operable Unit (northern 200 East Area)
- Section 2.11, 200-PO-1 Operable Unit (southern 200 East Area and downgradient contaminant plumes)
- Section 2.12, 300-FF-5 Operable Unit (300 Area and selected burial grounds)
- Section 2.13, 1100-EM-1 Groundwater Interest Area (former 1100 Area)
- Section 2.14, Confined Aquifers

Monitoring of specific units under the *Atomic Energy Act of 1954*; *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*; *Resource Conservation and Recovery Act of 1976*; or *Washington Administrative Code* are discussed within relevant sections.

Background information, including descriptions of regulatory requirements, waste sites, analytical methods, regional geology, and statistics, is published separately in a companion volume, PNNL-13080. This information formerly was included in annual groundwater reports, but was published separately to avoid repetition.

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# 2.1 Overview of Groundwater Flow

*J. P. McDonald*

This section provides a regional overview of groundwater flow beneath the Hanford Site. The uppermost aquifer beneath most of the Site is unconfined and is composed of unconsolidated to semiconsolidated sediment of the Hanford formation and Ringold Formation, which was deposited on the basalt bedrock. In some areas, deeper parts of the aquifer are confined locally by layers of silt and clay. Deeper confined aquifers also occur within the underlying basalt and associated sedimentary interbeds. Well location maps for each geographic region are included in Sections 2.2 through 2.14. Wells in the 600 Area, which cover portions of the Site other than the former operational areas, are shown in Figure 2.1-1.

During March 2008, 873 water-level measurements were collected from wells monitoring the unconfined aquifer system and the underlying confined aquifers beneath the Hanford Site. These data were used for the following:

- Prepare contour maps that indicate the general direction of groundwater movement within an aquifer
- Determine hydraulic gradients, which in conjunction with the hydraulic properties of the aquifer, are used to estimate groundwater flow velocities
- Interpret sampling results.

***During March 2008, 873 water-level measurements were collected across the Hanford Site. This information helps scientists understand the direction and rate of groundwater flow.***

This section describes the results of a regional-scale analysis of these data for the unconfined aquifer, which is the aquifer most affected by Hanford Site operations. Local groundwater flow in each groundwater operable unit is described in Sections 2.2 through 2.13. Flow characteristics in the confined aquifer present in the lower Ringold Formation and in the upper basalt-confined aquifer system are discussed in Section 2.14.

## 2.1.1 March 2008 Water-Table Map

Figure 2.1-2 presents the Hanford Site water-table map for March 2008. Groundwater in the unconfined aquifer generally flows from upland areas in the west toward the regional discharge area north and east along the Columbia River. Steep gradients occur in the west, east, and north regions of the Site. Shallow gradients occur southeast of the 100-F Area and in a broad arc extending from west of the 100-B/C Area toward the southeast between Gable Butte and Gable Mountain (Gable Gap) and the 200 East Area into the central portion of the Site. The steep gradients in the west and east are associated with low permeability sand and gravel of the Ringold Formation at the water table, while the low gradients are associated with highly permeable sand and gravel of the Hanford formation at the water table.

***Groundwater in the unconfined aquifer generally flows west to east beneath the Hanford Site and discharges to the Columbia River.***

North of Gable Butte and Gable Mountain, groundwater flow directions vary from northwest to east depending on the location. Groundwater enters this region through the gaps between Gable Mountain, Gable Butte, and Umtanum Ridge, as well as from natural recharge. The Columbia River also recharges the unconfined aquifer west of the 100-B/C Area. Water flowing north through Gable Gap spreads out and flows north-northwest toward the Columbia River, as well as toward the northeast and east along the north side of Gable Mountain. Recharge water from the Columbia River and the gap between Umtanum Ridge and Gable Butte is thought to flow east toward the 100-B/C Area and discharge to the river. In the 100 Area,

the local groundwater flow is generally toward the Columbia River, although this pattern is altered by pump-and-treat remediation systems in the 100-K, 100-D, and 100-H Areas. Between the 100-D and 100-H Areas, groundwater flow is toward the northeast.

An apparent groundwater mound exists ~2 km north of Gable Mountain and is associated with low conductivity Ringold Formation mud at the water table. This mound is contoured as if it were part of the unconfined aquifer (Figure 2.1-2), but it could represent a perched water table above the regional water table. More data is needed to distinguish between these alternatives. Water-level elevations indicate that groundwater moving east along Gable Mountain flows around this apparent mound.

South of Gable Butte and Gable Mountain, natural recharge to the aquifer comes from the Cold Creek Valley, Dry Creek Valley, Rattlesnake Hills, Yakima River, and infiltrating precipitation. Groundwater generally flows from west to east, although some of the flow from the 200 West Area or north of the 200 West Area turns north and flows through Gable Gap. Past effluent discharges at U Pond and other facilities caused a groundwater mound to form beneath the 200 West Area that significantly affected regional flow patterns in the past. These discharges largely ceased by the mid-1990s, but a remnant mound remains, which is apparent from the shape of the water-table contours passing through the 200 West Area. Currently, the water-table elevation is ~11 m above the estimated water-table elevation prior to the start of Hanford Site operations.[1] Equilibrium conditions will be re-established in the aquifer after dissipation of the mound caused by artificial recharge. When this occurs, the water table may still be ~5 to 7 m higher than in pre-Hanford times because of increased irrigation activities west of the Site. The water table beneath the 200 West Area is perturbed locally by discharges from the State-Approved Land Disposal Site, as well as by operation of a groundwater pump-and-treat remediation system at the 200-ZP-1 Operable Unit.

Groundwater flow in the central portion of the Hanford Site, encompassing the 200 East Area, is affected significantly by the presence of a buried flood channel, which is oriented from the northwest to the southeast (PNNL-12261, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington*). The water table in this area is very flat (i.e., the hydraulic gradient is estimated to be ~$10^{-5}$ or less) because of the high permeability of the Hanford formation. Groundwater flow in this region is affected significantly by the presence of low permeability sediment (i.e., muds) of the Ringold Formation at the water table east and northeast of the 200 East Area, as well as basalt above the water table. These features constitute barriers to groundwater flow. The extent of the basalt units above the water table continues to increase slowly because of the declining water table, resulting in an even greater effect on groundwater flow in this area. The water table beneath the 200 East Area is ~2.0 m higher than estimated pre-Hanford Site conditions.[2] When equilibrium conditions are re-established, the water table in the 200 East Area is expected to return to the pre-Hanford Site elevation.

1 Based on the March 2008 water-level elevation in well 299-W18-15 (136.2 m NAVD88) and the pre-Hanford Site water table elevation at the location of this well estimated from BNWL-B-360 (~125.1 m NAVD88). The peak historical water-level elevation within the 200 West Area occurred at well 299-W18-15 in 1984 (149.1 m NAVD88).

2 Based on the average water-level elevation measured in 31 wells within the 200 East Area during March 2008, all of which have been corrected for deviations of the boreholes from true vertical (122.02 m NAVD88), and the pre-Hanford Site water table elevation for the 200 East Area estimated from BNWL-B-360 (~120 m NAVD88).

Water enters the 200 East Area and vicinity from the west and southwest, as well as from beneath the mud units to the east and from the underlying aquifers where the confining units have been removed or thinned by erosion. The flow of water divides, with some flowing to the north through Gable Gap and some flowing southeast toward the central part of the Site. The specific location of the groundwater flow divide is not certain, because the flat nature of the water table in the 200 East Area makes determining flow directions difficult (Section 2.1.3). It is known that groundwater flows north through Gable Gap, because the hydraulic gradient within the gap area is large enough to be determined using water-level data. During fiscal year (FY) 2008, the gradient in Gable Gap averaged $8.1 \times 10^{-5}$ along a north flow direction, but flow conditions vary during the year because of changes in the Columbia River stage (Section 2.1.4). Groundwater is inferred to flow southeast within the region between the 200 East Area and the Central Landfill, because the average water-level elevation at the landfill (121.88 m NAVD88 for March 2008) is 0.14 m less than the average elevation in the 200 East Area (122.02 m NAVD88 for March 2008). This yields a regional hydraulic gradient of $1.8 \times 10^{-5}$.

***The flat water table in the 200 East Area makes determination of flow directions difficult.***

Between the area southeast of the Central Landfill to the 300 Area, the highly permeable sediments of the Hanford formation occur above the water table. These sediments intercept the water table again at the 300 Area. For this reason, the hydraulic gradient in the 300 Area is also very low. Groundwater flow converges on the 300 Area from the northwest, west, and southwest, then generally moves along a southeast flow path and discharges to the Columbia River (PNNL-15127, *Contaminants of Potential Concern in the 300-FF-5 Operable Unit: Expanded Annual Groundwater Report for Fiscal Year 2004*).

## 2.1.2 Water Table Change from FY 2007

The water-table elevation continued to decline over much of the Site from March 2007 to March 2008. The decline is a result of the curtailment of effluent discharges to the ground during the 1980s and 1990s. (DOE/RL-2008-01, Section 2.1.3 provides a discussion of the water table change from 1979 to 2007.) The largest widespread decreases occurred to the west of the 200 West Area, where the water-table elevation decreased by an average of 0.42 m. In previous years, the water-table elevation had increased in Dry Creek Valley and along the Yakima River, signifying increased recharge to the aquifer from these areas. During FY 2008, declines from 0.01 to 0.04 m were observed in all but one well in these areas. Water levels also increased in places along the Columbia River because of river stage fluctuations.

***Over much of the Hanford Site, the water table continued to decline. The declining water table caused some monitoring wells to go dry; new wells are being installed.***

In the 200 West Area, the water table declined by an average of 0.27 m (in areas not influenced by the 200-ZP-1 Pump-and-Treat System). Larger declines were observed near the 200-ZP-1 Pump-and-Treat System, especially at the single-shell T Tank Farm where additional extraction wells recently began operating. In the 200 East Area, the elevation of the water table declined only slightly by an average of 0.01 m, which was less than the decline of 0.06 m observed the previous year (DOE/RL-2008-01). In addition, the water-table elevation increased to both the north and south of the 200 East Area between March 2007 and March 2008. During late FY 2007, the water-table elevation increased over much of the 200 East Area (Figure 2.1-3), and was attributed to increased effluent discharges at the Treated Effluent Disposal Facility (DOE/RL-2008-01). The smaller decline within the 200 East Area during FY 2008

and the observed increases adjacent to the 200 East Area may be from the lingering influence of the increased effluent discharges.

## 2.1.3 Water-Level Monitoring in the 200 East Area

Regulations require that water-level measurements be used to determine the groundwater flow direction beneath RCRA regulated waste sites at least annually. In the 200 East Area, existing water-level measurements have not been accurate enough to determine the flow direction because of the small hydraulic gradient magnitude and large depth to water. However, progress has been made in recent years on improving the accuracy of the water-level measurements to allow for hydraulic gradient determinations.

The feasibility of collecting highly accurate water-level measurements was investigated at Low-Level Waste Management Area 1 in the northwest corner of the 200 East Area. Section 2.10 provides more information on the facility's location. Highly accurate casing elevation surveys and borehole deviation surveys were performed for a network of 14 wells at this site. The borehole deviation surveys map the position of the borehole in 3 dimensional space and enable the difference between the measured depth to water and the true vertical depth to water to be determined. Water-level measurements were collected periodically, and trend-surface analyses were performed to determine the plane that best fits the water-level elevations. The largest source of error in the water-level measurements was found to be deviation of the boreholes from true vertical. Sixteen sets of water-level measurements were collected between September 2005 and September 2008. Using the new casing elevations and correcting for borehole deviation, the trend-surface analysis results were statistically significant for 11 of the data sets at a 5% level of significance, and for 15 of the data sets at a 10% level of significance. From September 2005 through June 2008, the average groundwater flow direction was to the north-northwest (340° ± 10° azimuth). However, in August and September 2008, a southern flow direction was indicated and was likely a result of high stage in the Columbia River during June. Lower than normal effluent discharges to the Treated Effluent Disposal Facility, located east of the 200 East Area, also may have been a factor (PNNL-16346, *Hanford Site Groundwater Monitoring for Fiscal Year 2006*, Section 2.1.3).

A similar water-level study is being performed in the southeast corner of the 200 East Area for the Integrated Disposal Facility and the RCRA PUREX Cribs (216-A-10 and 216-A-36B). Section 2.11 provides more information on the facilities' locations. Highly accurate casing elevation surveys and borehole deviation surveys were performed for a network of 11 wells at this site. Four sets of water-level measurements were collected between June 2008 and the end of the fiscal year. The data exhibited more variability than was observed at Low-Level Waste Management Area 1. Therefore, additional measurements are required before a flow direction determination can be made. Water-level measurements will continue at both Low-Level Waste Management Area 1 and the Integrated Disposal Facility/ RCRA PUREX Cribs during FY 2009. In addition, a water-level study is planned for Low-Level Waste Management Area 2 in the northeast corner of the 200 East Area during FY 2009.

## 2.1.4 Water-Level Monitoring in Gable Gap

Periodic collection of water-level measurements from a network of six wells within Gable Gap continued during FY 2008. These measurements were used to determine the hydraulic gradient response to seasonal changes in Columbia River stage, because Gable Gap may represent a transport pathway for contaminants migrating north from the 200 East Area. Changes in groundwater flow through Gable Gap may affect the water-table elevation within the 200 East Area (PNNL-16346). Wells 699-60-60, 699-61-62, 699-61-66, 699-64-62, 699-65-72, and 699-66-64 were used for this study (Figure 2.1-4).

The water-level elevation data were analyzed using trend-surface analysis, in which the plane that best fits the water-level elevations was determined. The direction and magnitude of the dip of the plane approximates the regional hydraulic gradient within the study area. During the initial analysis of all six wells, most of the results were not statistically significant, indicating a plane was not a good representation of the water table across all six wells. Additional analyses indicated that well 699-65-72 exerted a substantial influence on the trend surface results since it responded more quickly to river stage changes than the other wells (Figure 2.1-5). This well is located more to the west of Gable Gap and closer to the river than the other wells. After omitting well 699-65-72 from the final trend-surface analyses, 12 of 21 data set results were statistically significant for FY 2008.

***Groundwater levels in Gable Gap vary in response to seasonal changes in Columbia River stage.***

The water-level monitoring results in Gable Gap for FY 2008 confirmed the findings presented in the previous annual report (DOE/RL-2008-01). During FY 2008, the water-table elevation within the Gable Gap area responded to seasonal changes in Columbia River stage, similar to FY 2006 and FY 2007 (Figure 2.1-5). A time lag is associated with the response. The data for well 699-65-72 exhibits an ~2-month time lag, while the remaining wells exhibit an ~3-month time lag. The magnitude and direction of the hydraulic gradient also changed in response to the seasonal fluctuation of water levels (Figure 2.1-6). The largest gradient magnitudes ($\sim 1 \times 10^{-4}$) are associated with periods of low river stage, while the smallest gradients ($\sim 4 \times 10^{-5}$) occur with periods of high river stage (following a 3-month time lag). The direction of the gradient also changed seasonally. A flow direction to the north was associated with low river stage, while a northeast flow direction was associated with high river stage. Figure 2.1-7 presents a rose diagram of groundwater flow directions in Gable Gap for FY 2008. The figure depicts the percentage of time when groundwater flowed in various directions in 10° segments. The average hydraulic gradient in Gable Gap during FY 2008 was calculated to be $8.1 \times 10^{-5}$ and the average direction (time weighted) was 003° azimuth (north).

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**Figure 2.1-1. Groundwater Monitoring Wells on the Hanford Site.**

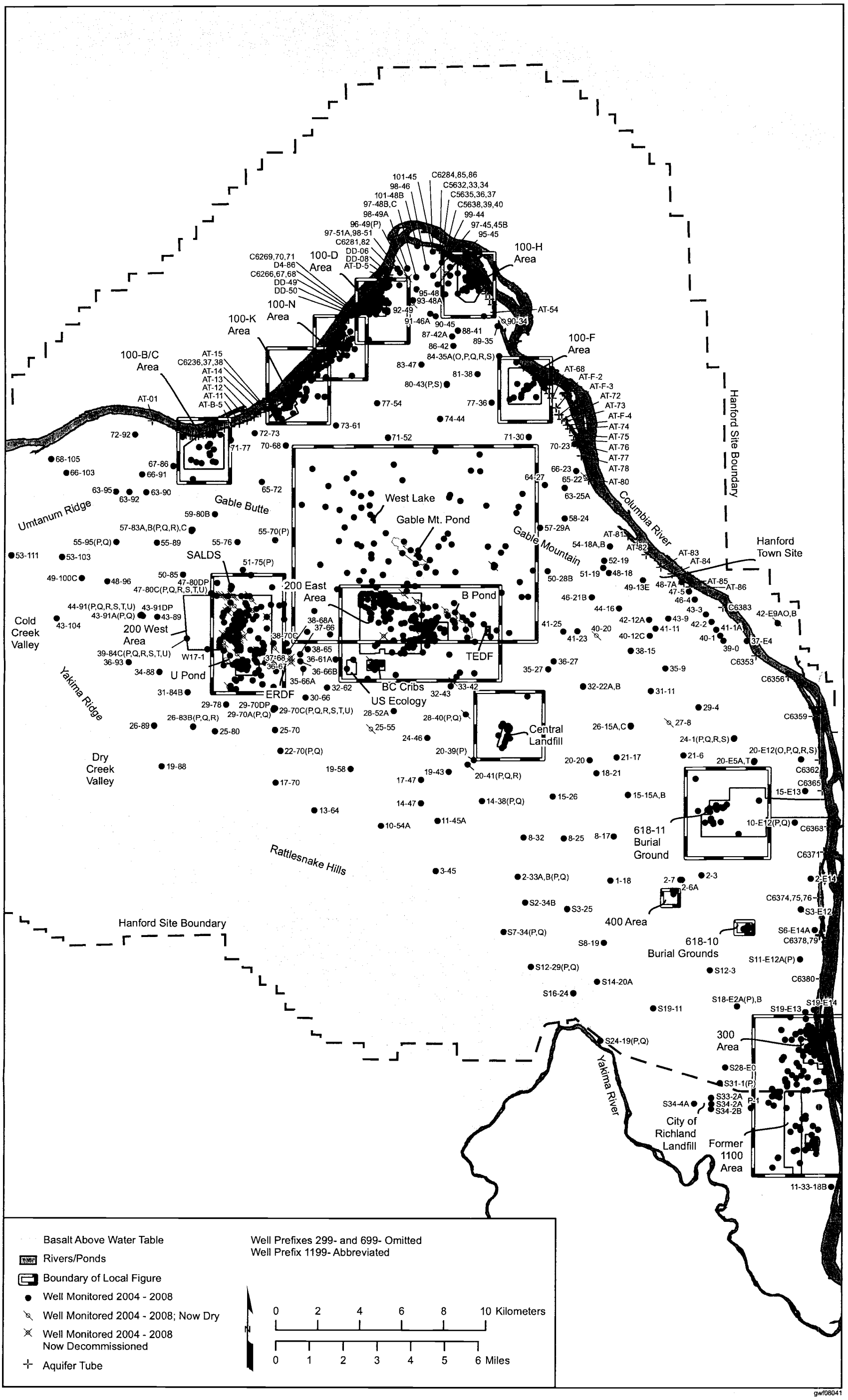


**Figure 2.1-2. Hanford Site Water-Table Map, March 2008.**

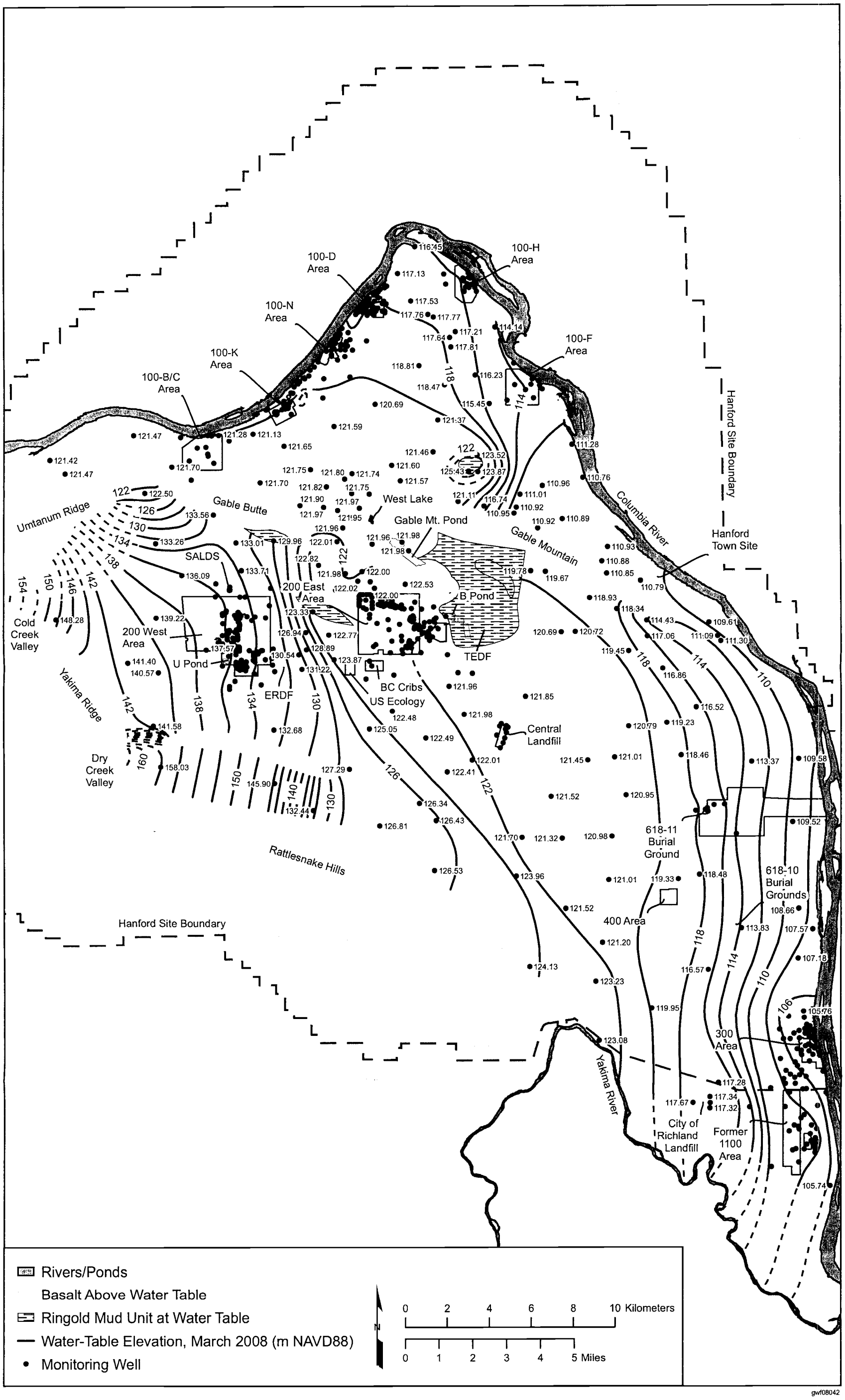


**Figure 2.1-3. 200 East Area Water-Table Elevations, FY 2007 and FY 2008.**

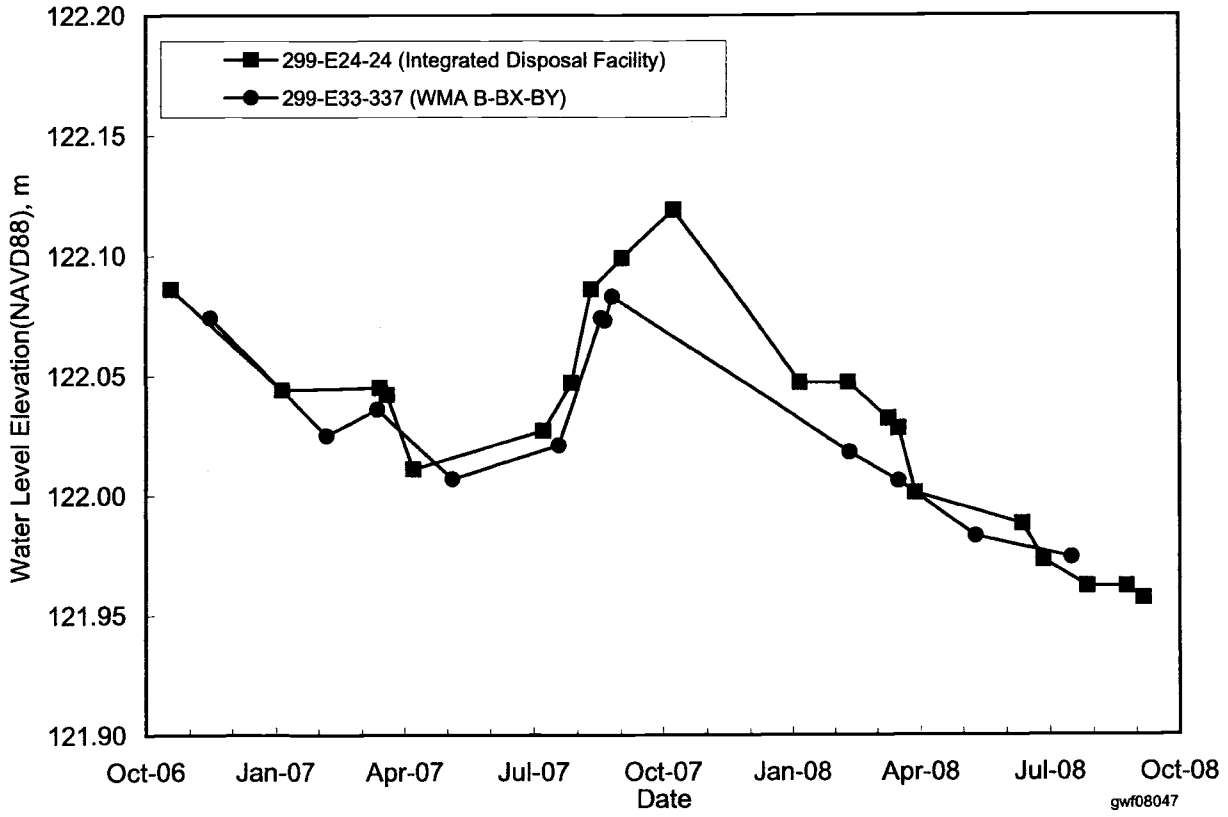


**Figure 2.1-4. Locations of Wells for the Water-Level Monitoring Study in Gable Gap.**

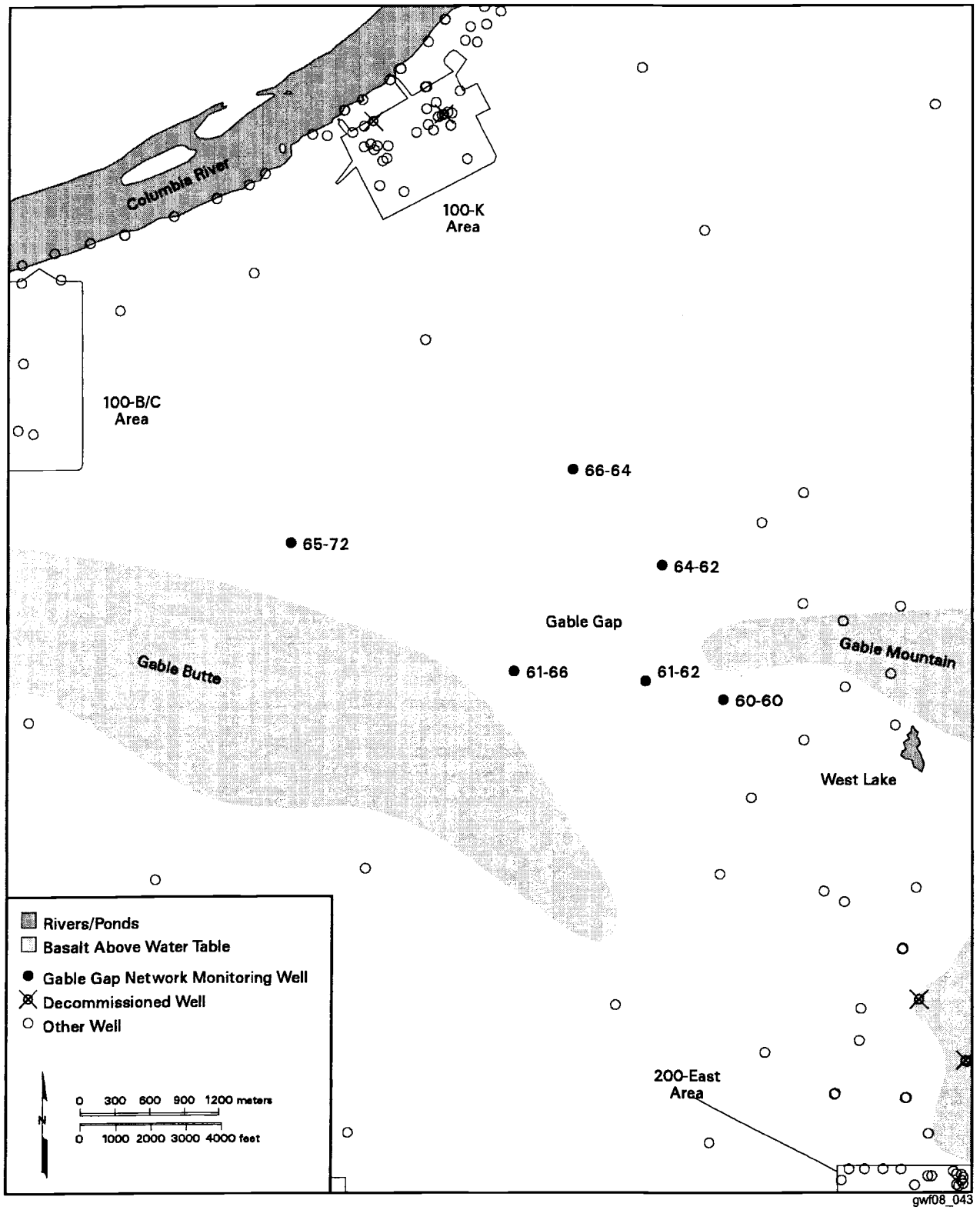


**Figure 2.1-5. Correlation Between Columbia River Stage and Water-Level Elevations in Gable Gap.**

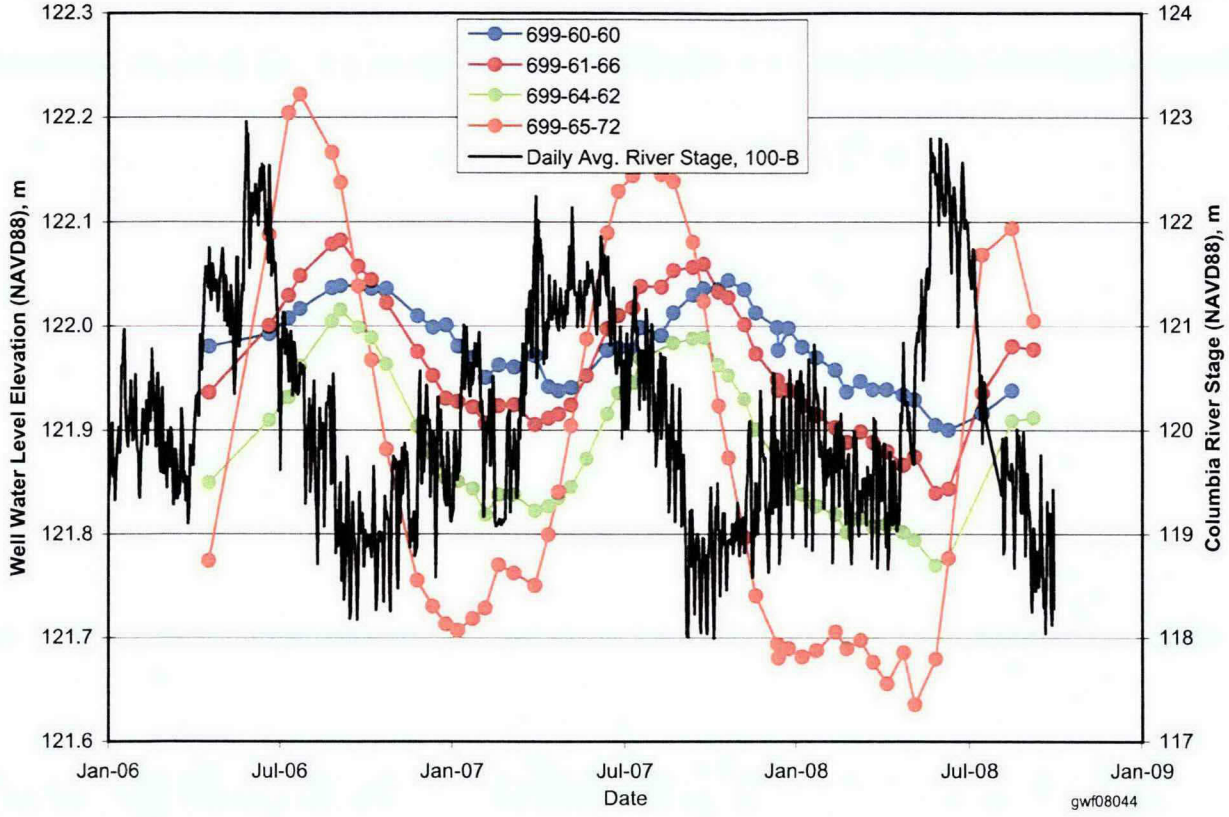



**Figure 2.1-6. Variability of the Magnitude and Direction of the Hydraulic Gradient in Gable Gap.**

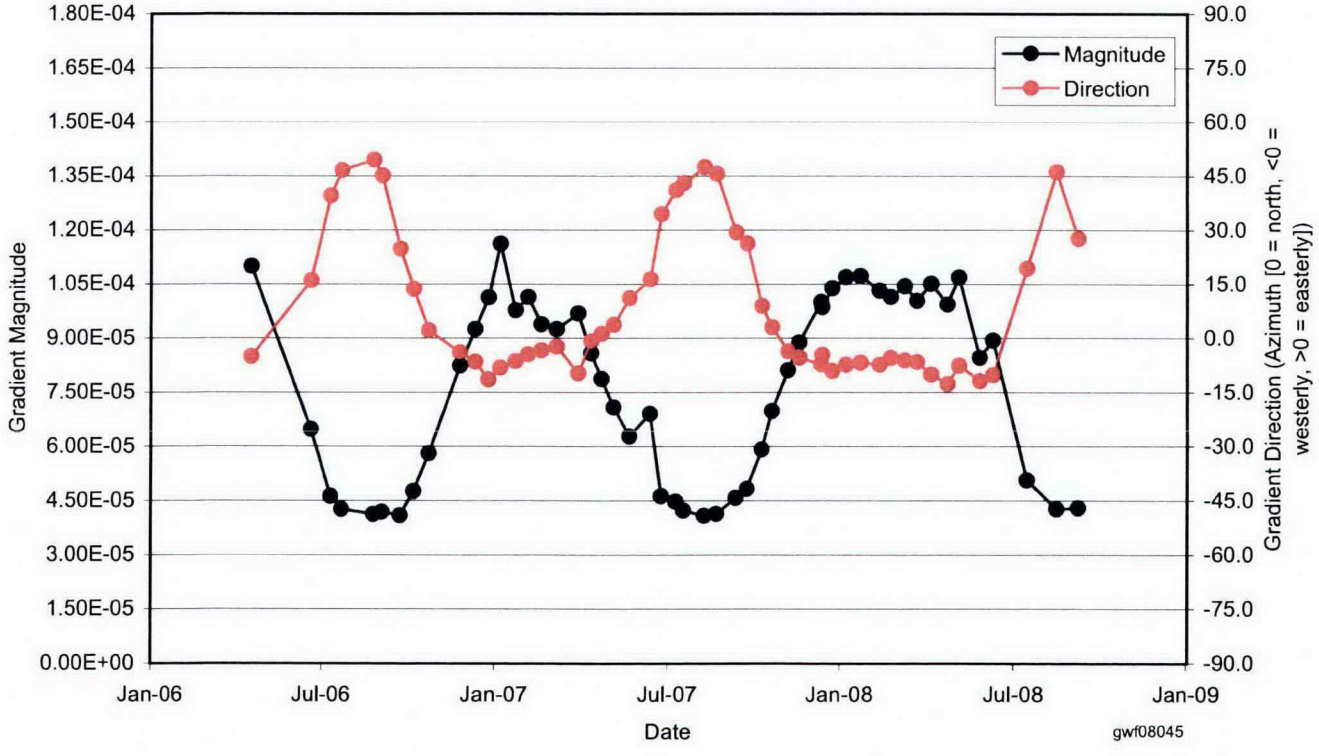
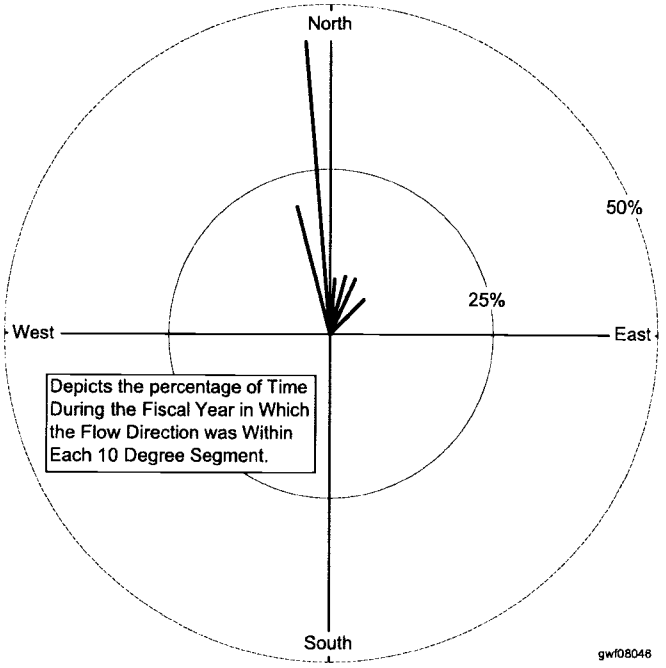


**Figure 2.1-7. Histogram/Rose Diagram of Groundwater Flow Directions in Gable Gap, FY 2008.**



# 2.2 100-BC-5 Operable Unit

***M. J. Hartman***

This section describes groundwater flow and chemistry in the vicinity of the 100-B/C Area. Figure 2.2-1 shows facilities, wells, and shoreline monitoring sites in the 100-B/C Area.

Groundwater enters the 100-B/C Area from upgradient areas along the Columbia River and the gaps between Umtanum Ridge, Gable Butte, and Gable Mountain. Groundwater flows primarily to the north beneath the 100-B/C Area and discharges to the Columbia River (Figure 2.2-2). The hydraulic gradient is very flat in the southern 100-B/C Area and in the western part of the interest area.

Some of the main concepts associated with the 100-BC-5 Operable Unit include the following.

- Strontium-90, hexavalent chromium, and tritium plumes are present in groundwater at levels above drinking water or aquatic standards.
- Previous assessments have not identified groundwater conditions that warrant interim remedial measures. Final decisions on groundwater cleanup will be reached in coming years.
- Most of the former waste sites have been remediated (shallow contaminated sediment has been excavated) and backfilled. Remediation is ongoing at remaining sites.
- Chromium contamination was detected in the deep vadose zone at one former waste site. The U.S. Department of Energy (DOE) is investigating alternatives for vadose zone remediation.
- All but one of the monitoring wells are screened at the top of the unconfined aquifer, which is ~34 m thick in the 100-B/C Area. One well is screened ~38 m below the water table in the Ringold upper mud unit, and has not had any detected contamination.

The following sections provide details about the operable unit activities. Sections 2.2.1 and 2.2.2 describe contaminant plumes and concentration trends for the contaminants of concern and operable unit activities, respectively. Groundwater monitoring for the *Atomic Energy Act of 1954* (AEA) is integrated fully with *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) monitoring. There are no active waste disposal facilities or *Resource Conservation and Recovery Act of 1976* sites in the 100-B/C Area.

## 2.2.1 Groundwater Contaminants

Wells in the 100-BC-5 Operable Unit are sampled for the contaminants of concern based on results of the data quality objectives process (PNNL-14287, *Data Quality Objectives Summary Report – Designing a Groundwater Monitoring and Assessment Network for the 100-BC-5 and 100-FR-3 Operable Units*): strontium-90, tritium, and hexavalent chromium. This section describes distribution and trends of the groundwater contaminants of concern and nitrate beneath the 100-BC-5 groundwater interest area.

***Plume areas (square kilometers) in the 100-BC-5 Operable Unit:***
***Chromium, 20 µg/L — 0.85***
***Strontium-90, 8 pCi/L — 0.63***
***Tritium, 20,000 pCi/L — 0.22***

### 2.2.1.1 Strontium-90

A wedge-shaped plume of strontium-90 extends from the central 100-B/C Area north toward the Columbia River (PNNL-15670, *Hanford Site Groundwater Monitoring for Fiscal Year 2005,* Figure 2.2-3 provides a 2005 plume map). The drinking water standard is 8 pCi/L. The plume has not changed significantly for more than 10 years. Figure 2.2-3 shows strontium-90 trends in wells near the 116-B-1 Trench, the 116-C-1 Trench, and cribs in the central 100-B/C Area. The highest concentration in fiscal year (FY) 2008 was 44.7 pCi/L in well 199-B3-46, near the 116-C-1 Trench. Concentrations in FY 2008 were about the same as the previous year. Long-term trends are steady or declining.

***Strontium-90 and tritium exceeded drinking water standards in groundwater at the 100-BC-5 Operable Unit during FY 2008.***

Strontium-90 levels in four aquifer tubes exceeded the drinking water standard in FY 2008, with a maximum of 16 pCi/L in new tube C6230, sampled for the first time in September 2008. Concentration trends in the older aquifer tubes are steady to gradually declining.

Strontium-90 appears to be limited to the upper part of the unconfined aquifer. Deep well 199-B2-12 consistently has no detectable strontium-90, while its shallow counterpart, well 199-B3-47, has levels above the drinking water standard. Similarly, deep aquifer tubes C6332, AT-05-D, and AT-06-D had undetectable strontium-90 concentrations, while their shallower counterparts had concentrations above the drinking water standard.

### 2.2.1.2 Tritium

The upper part of the unconfined aquifer beneath the 100-B/C Area is contaminated with tritium at concentrations that exceed the drinking water standard (20,000 pCi/L) in several wells (Figure 2.2-4). The distribution of tritium currently is interpreted as three separate plumes.

In the northern 100-B/C Area, only well 199-B3-47 had a tritium concentration above the drinking water standard during FY 2008 (45,000 pCi/L; Figure 2.2-5). Wells 199-B4-1 and 199-B5-2 had concentrations below the standard, though they have exceeded the standard in the past. The FY 2008 increase in well 199-B3-47 may represent the pulse of tritium seen in well 199-B5-2 in 2005 and 2006.

The northern tritium plume is detected at the Columbia River in aquifer tubes. New tube C6231 had the highest aquifer tube concentration (20,000 pCi/L) in FY 2008. Concentrations have declined in the past 10 years in nearby tube AT-06-D. In 1998, the concentration in this aquifer tube was 66,000 pCi/L and in FY 2008 18,000 pCi/L.

***Tritium concentrations exceeded the drinking water standard in three plumes in the 100-B/C Area.***

Tritium concentrations in three wells in the southern 100-B/C Area exceed the drinking water standard (Figure 2.2-6). The current interpretation is that there are two separate plumes in this region. Because the area has only three monitoring wells, these plumes are not well defined. Well 199-B8-6 (near the 118-B-1 Burial Ground) had tritium concentrations of ~29,000 pCi/L, with a flat trend over the past few years. Wells 199-B8-7 (between wells 199-B8-6 and 199-B8-8) and 199-B8-8 (in the 100-C-7 Waste Site) also had tritium levels above the standard. The wells were sampled monthly from September 2007 through January 2008, and quarterly for the rest of FY 2008 (April and July). The source of this tritium is unknown, because the nearby waste sites are not known sources of tritium. The 118-B-1 Burial Ground does not seem a likely source for the tritium in wells 199-B8-7 and 199-B8-8 because it is not upgradient of the wells. The DOE will continue to monitor the new wells for tritium and other constituents (Appendix A).

Just east of the 100-B/C Area, tritium concentrations at tube sites AT-B-5 and AT-B-7 remained elevated (~14,000 pCi/L), but were below the drinking water standard. Tritium east of the 100-B/C Area is believed to represent a plume from the 200 Area that migrated northward. Elevated tritium concentrations also were observed in well 699-72-73, east of the 100-B/C Area. The FY 2008 result was 15,000 pCi/L.

### 2.2.1.3 Chromium

Hexavalent chromium is of potential concern to salmon and other aquatic life. The aquatic standard for hexavalent chromium is 10 μg/L. Chromium concentrations continued to be below the drinking water standard (100 μg/L for total chromium), but exceeded 10 μg/L in wells and aquifer tubes in the eastern half of the 100-B/C Area. The dimensions of this plume did not change between FY 2007 and FY 2008 (Figure 2.2-7). The highest concentration was 54.8 μg/L (hexavalent chromium) in well 199-B3-47, downgradient of the 116-B-11 Retention Basin. This result was within the range observed since 1999.

***Chromium concentrations increased in one well monitoring the 100-C-7 Waste Site in FY 2008.***

In the southern 100-B/C Area, waste site investigations discovered chromium contamination in the vadose zone at the 100-C-7 Waste Site (Figure 2.2-1). Chromium concentrations for groundwater samples from wells 199-B8-7 and 199-B8-8 initially were under 20 μg/L. The concentration increased to 49 μg/L in well 199-B8-8 in July 2008 (Figure 2.2-8), but declined in October 2008. This well will be sampled monthly in FY 2009 to monitor chromium levels.

Another waste site, 100-B-27 sodium dichromate spill, located in the northwestern 100-B/C Area, also had chromium contamination in the vadose zone. The DOE drilled a characterization borehole and collected soil and groundwater samples from this waste site (WCH-225, *Sampling and Analysis Instruction for Evaluation of Residual Hexavalent Chromium Contamination in the Subsurface Soil at 100-B-27*). Chromium levels in groundwater were low (6.5 μg/L in a filtered sample).

Deep monitoring well 199-B2-12, located adjacent to shallow well 199-B3-47, has no detectable chromium. Figure 2.2-9 illustrates the distribution of chromium concentrations with depth for the 100-B/C Area aquifer tubes and nearby wells. In FY 2008, the highest concentrations in aquifer tubes were in shallow tube AT-05-S and mid-depth tube AT-06-M (both 46 μg/L).

### 2.2.1.4 Nitrate

DOE/RL-2005-40, *100-B/C Pilot Project Risk Assessment Report*, identified nitrate as a contaminant of concern, because of its exceedance of the drinking water standard (45 mg/L) in well 199-B3-47 in 1998 and 1999. Concentrations subsequently have decreased. The highest nitrate concentration in FY 2008 was 39.5 mg/L in well 199-B3-47, about the same as in FY 2007.

## 2.2.2 Operable Unit Activities

Groundwater sampling requirements are defined in the groundwater sampling and analysis plan (DOE/RL-2003-38, *100-BC-5 Operable Unit Sampling and Analysis Plan*) and a Tri-Party Agreement change notice (TPA-CN-182). The wells, aquifer tubes, and seeps scheduled for sampling in FY 2008 were sampled as planned (Appendix A). The DOE installed and sampled nine new aquifer tubes (in three

clusters) in FY 2008 (SGW-36398, *Installation and Sampling Analysis Instructions for Fiscal Year 2008 Aquifer Tubes*).

Groundwater sampling in FY 2009 will be modified by another Tri-Party Agreement change notice. Aquifer tube sampling requirements for FY 2009 are specified in an upcoming revision of DOE/RL-2000-59.

The DOE plans to install several new wells in the 100-B/C Operable Unit. Data from these sites will help define groundwater quality near recently characterized waste sites.

***Groundwater monitoring in the 100-BC-5 groundwater interest area includes integrated CERCLA and AEA monitoring.***

- ***Twenty-five wells are scheduled for quarterly to biennial sampling.***
- ***Fourteen aquifer tube sites and two seeps are scheduled for annual sampling.***
- ***Nine new aquifer tubes were installed and sampled in FY 2008. They are scheduled for annual sampling.***

**Figure 2.2-1. Facilities and Groundwater Monitoring Wells in 100-B/C Area.**

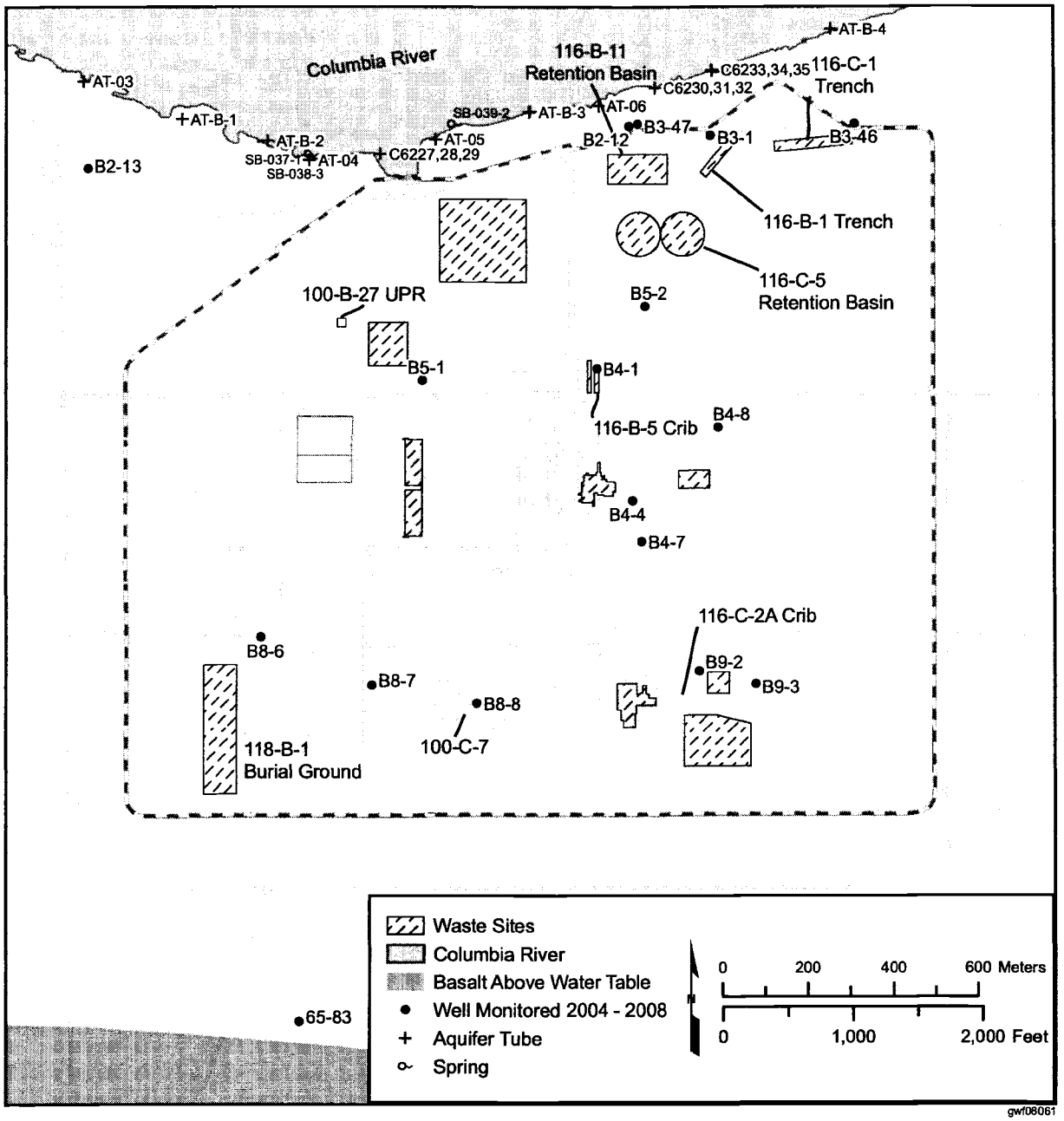


**Figure 2.2-2. 100-B/C Area Water-Table Map, March 2008.**

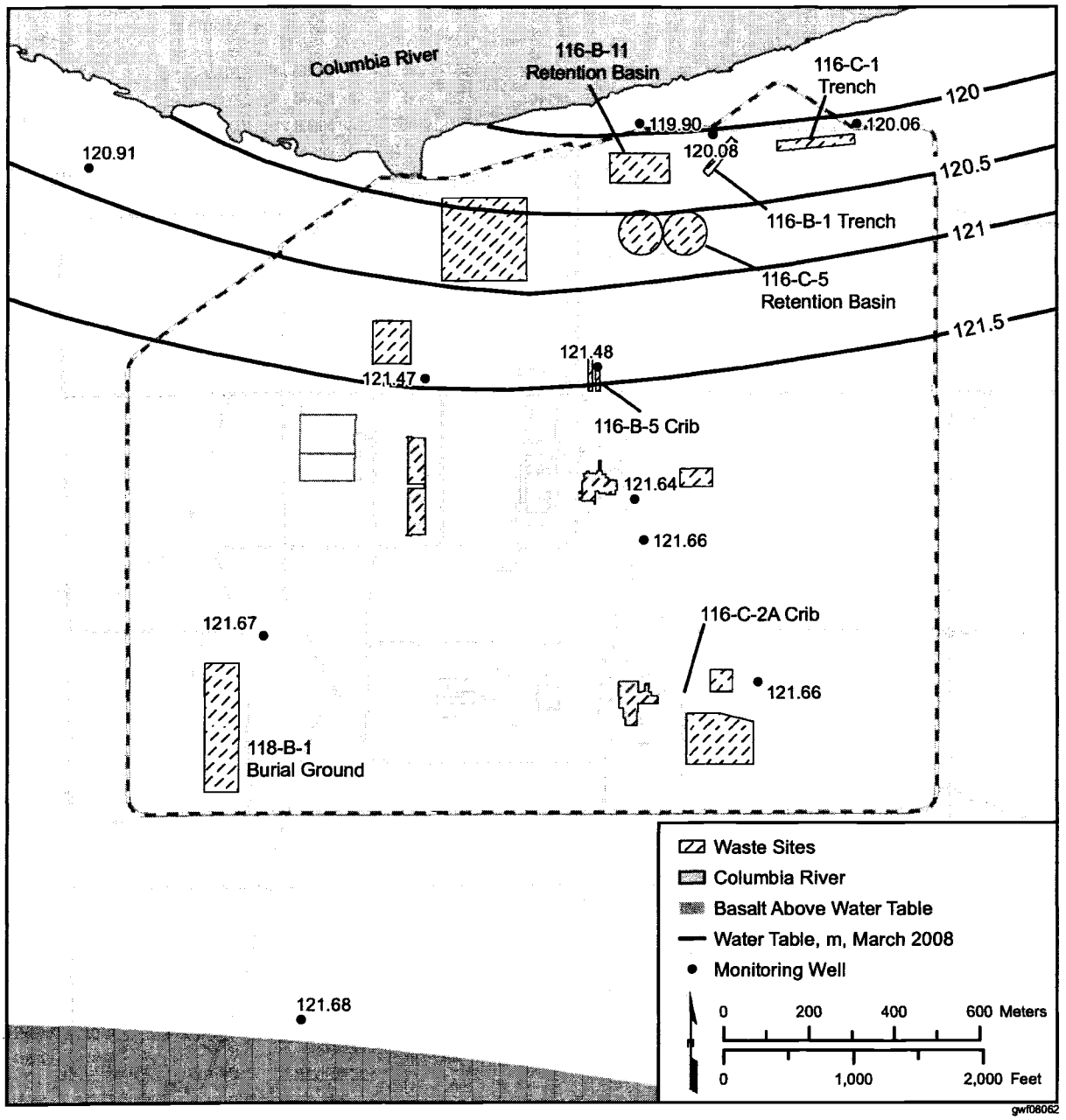


**Figure 2.2-3. Strontium-90 Concentrations in the 100-B/C Area.**

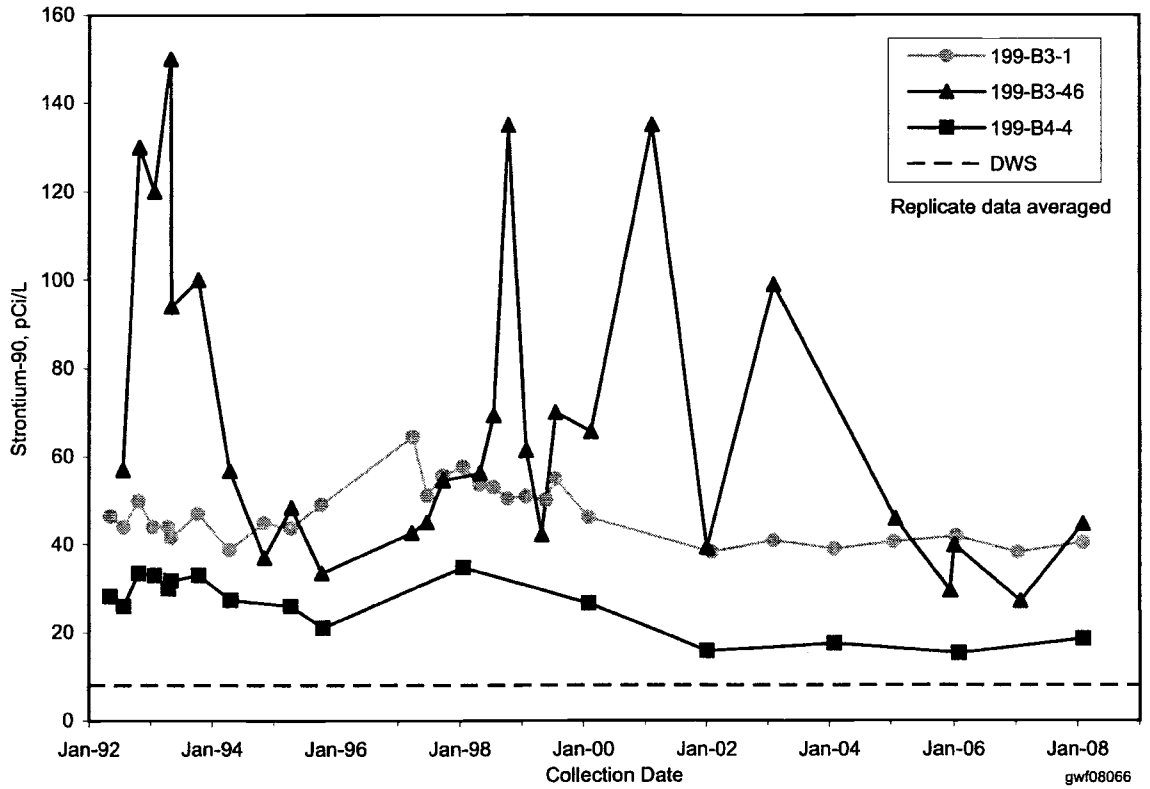


**Figure 2.2-4. Average Tritium Concentrations in 100-B/C Area, Upper Part of Unconfined Aquifer.**

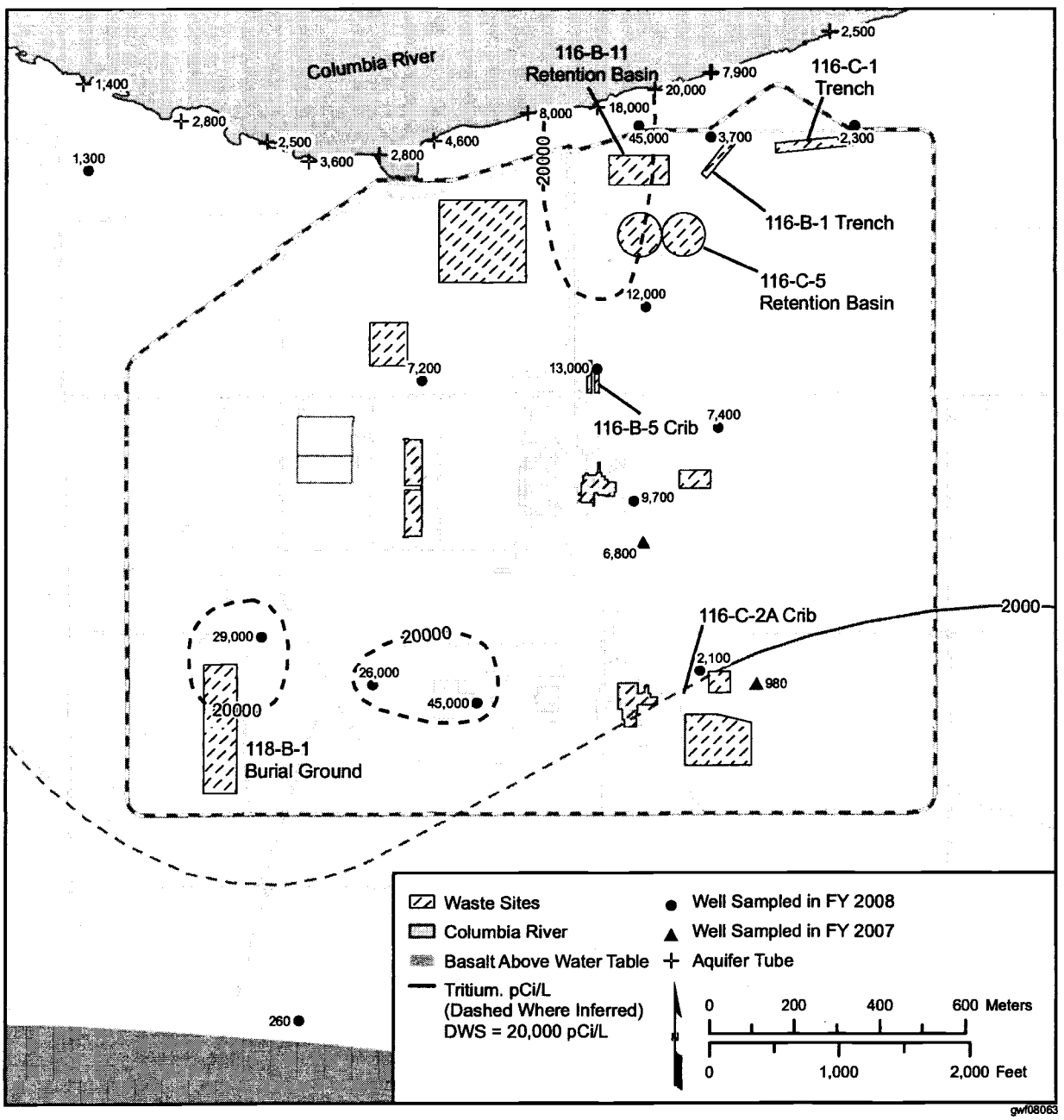


**Figure 2.2-5. Tritium Concentrations in Northern 100-B/C Area.**

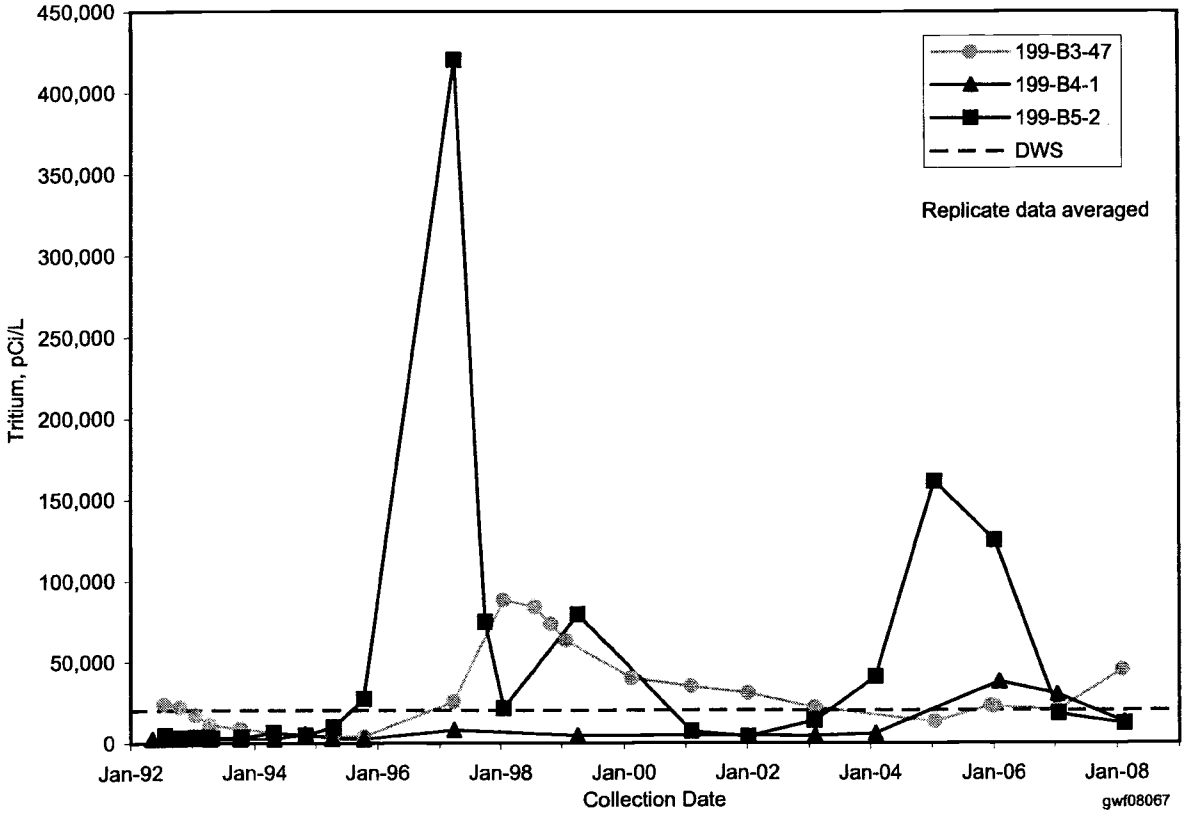



**Figure 2.2-6. Tritium Concentrations in Southern 100-B/C Area.**

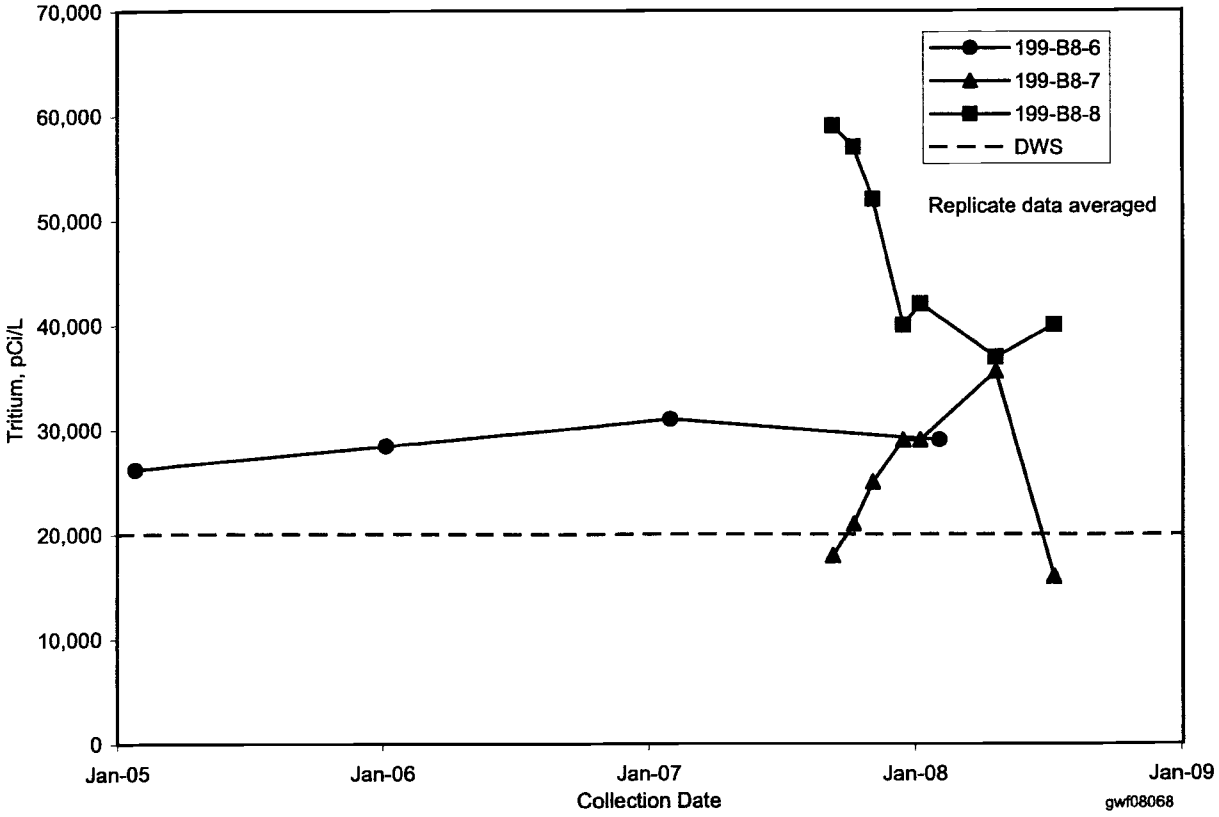


**Figure 2.2-7. Average Chromium Concentrations in 100-B/C Area, Upper Part of Unconfined Aquifer.**

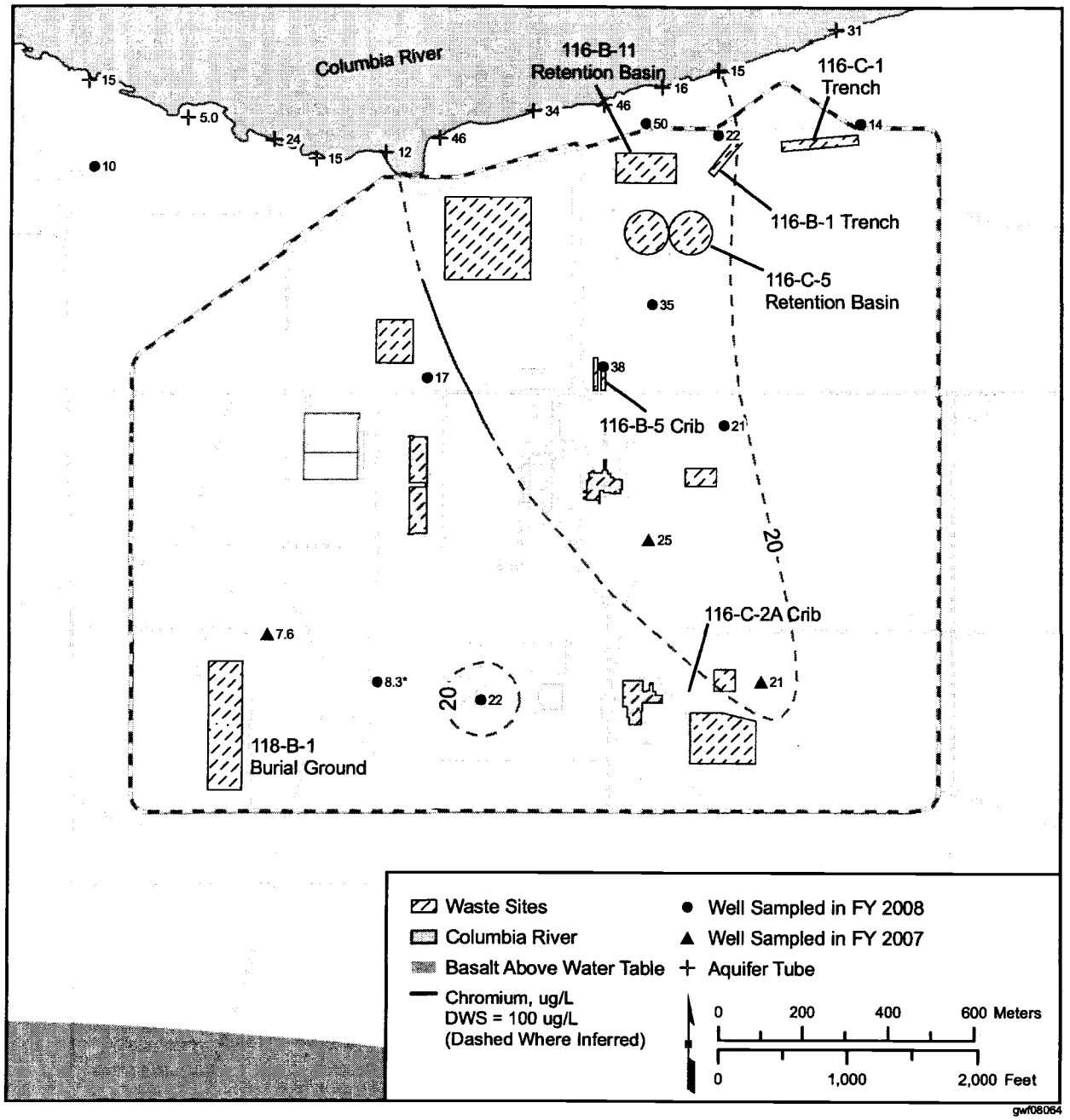


**Figure 2.2-8. Hexavalent Chromium Concentrations in Wells near the 100-C-7 Waste Site.**

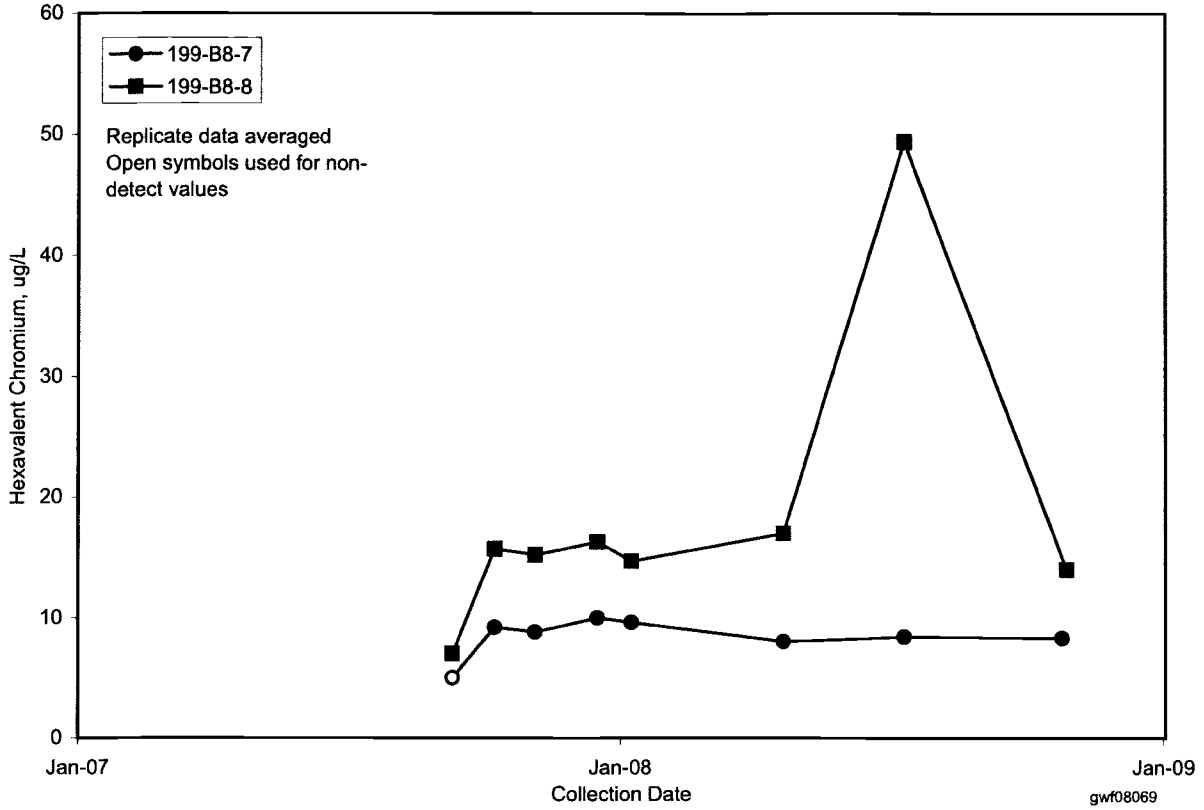
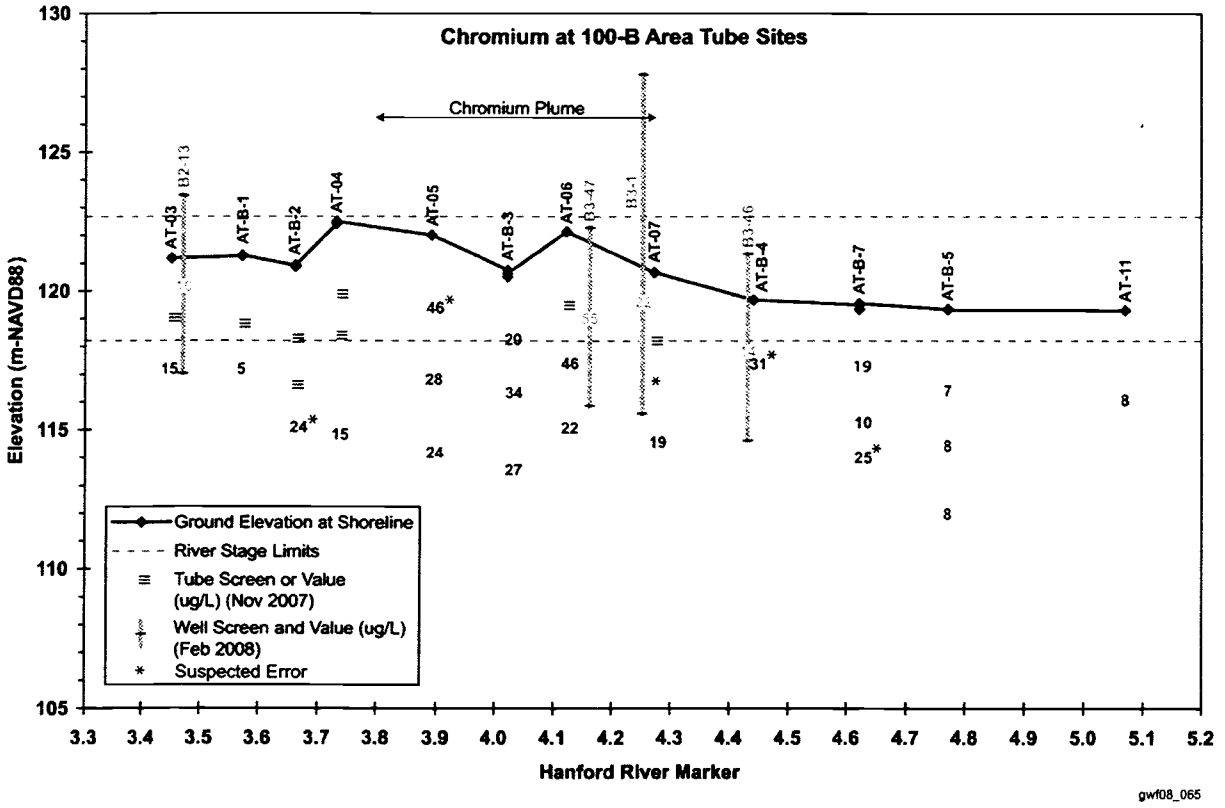



**Figure 2.2-9. Cross Section of Chromium Concentrations and Screen Elevations in Wells and Aquifer Tubes in 100 B/C Area.**



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# 2.3 100-KR-4 Operable Unit

***M. J. Hartman***

The 100-KR-4 Operable Unit includes groundwater affected by contaminant releases from facilities and waste sites within the 100-K Area. Most of the facilities and waste sites are associated with former operation of the KE and KW Reactors and their support facilities. The operable unit lies within a larger 100-KR-4 groundwater interest area, informally defined to facilitate scheduling, data review, and interpretation (Figure 1.0-1). Figure 2.3-1 shows facilities, monitoring wells, shoreline monitoring sites, and waste sites.

Groundwater beneath the 100-K Area generally flows toward the northwest to the Columbia River (Figure 2.3-2). Groundwater flow in 100-K Area is affected by two pump-and-treatment systems. The larger system has extraction wells between the 116-K-2 Trench and the Columbia River and injection wells upgradient of the trench. A water-table mound has formed, causing a radial flow pattern to develop around the injection sites. The mound (Figure 2.3-2) was estimated using an analytical method that considered injection rates, transmissivity, and specific yield, as documented in PNNL-14031, *Evaluation of Potential Sources for Tritium Detected in Groundwater at Well 199-K-111A, 100-K Area*. A second pump-and-treat system is located downgradient of the KW Reactor building. Treated water is injected into wells south (upgradient) of the reactor building.

***Hexavalent chromium is the principal contaminant of concern in 100-K Area groundwater. Two pump-and-treat systems are cleaning up the aquifer.***

An upward hydraulic gradient exists in the 100-K Area near the Columbia River, based on data from wells 199-K-32A and 199-K-32B. Well 199-K-32B is completed ~31 m deeper than well 199-K-32A. The upward gradient in March 2008 was 0.09, and in July 2008 was 0.08.

Some of the main concepts associated with the 100-KR-4 Operable Unit include the following.

- Principal sources of groundwater contamination included former liquid waste disposal facilities (trenches, cribs, fuel retention basins). These facilities are inactive, but contamination remains in the vadose zone.
- Contaminated shielding water was removed from KE Basin, which had leaked in the past, and the basin was filled with a sand-grout mixture. The KW Basin remains water-filled, but there is no evidence that it has leaked.
- Hexavalent chromium is the principal contaminant of concern in groundwater. The contamination is distributed in three plumes. Two of them are being remediated by pump-and-treat systems.
- The pump-and-treat systems removed 33.2 kg of chromium in fiscal year (FY) 2008, and 361 kg since 1997. Concentrations in groundwater remained above the remedial action goal of 22 μg/L in some wells. The U.S. Department of Energy (DOE) is expanding the pump-and-treat systems to improve their effectiveness.
- The largest chromium plume in 100-K Area is shrinking and concentrations are decreasing overall.
- Carbon-14, nitrate, strontium-90, and tritium contamination also is present in groundwater at concentrations above drinking water standards.

- Twenty-seven new wells were installed in FY 2008. Two of these detected higher levels of tritium contamination than previously recorded.
- All but one of the monitoring wells are screened at the top of the unconfined aquifer, which is ~27 m thick in the 100-K Area. One well is screened ~34 m below the water table in the Ringold upper mud unit, and it does not detect any contamination.

The following sections provide details about the operable unit activities. Groundwater monitoring in the 100-K Area is conducted under two regulatory drivers: the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) governs the 100-KR-4 Operable Unit, while the *Atomic Energy Act of 1954* provides the basis for monitoring the fuel storage basins at each reactor building (i.e., KE and KW Basins). CERCLA requirements are further subdivided into monitoring conducted to characterize and track contaminants of concern or potential concern in the operable unit, and evaluate the performance of the pump-and-treat systems that remove hexavalent chromium from groundwater. There are no *Resource Conservation and Recovery Act of 1976* sites requiring groundwater monitoring in the 100-K Area.

## 2.3.1 Groundwater Contaminants

Wells in the 100-KR-4 Operable Unit are sampled for constituents of concern provided in EPA/ROD/R10-96/134, *Declaration of the Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units*. Hexavalent chromium has been identified as a contaminant of concern that warrants interim remedial action. This contaminant is of potential concern to salmon and other aquatic life. Other constituents of interest in the operable unit include tritium, carbon-14, strontium-90, nitrate, and trichloroethene. These constituents are being monitored during waste sites remediation and facility decontamination and decommissioning.

***Plume areas (square kilometers) in the 100-KR-4 Operable Unit:***
***Carbon-14, 2,000 pCi/L — 0.09***
***Chromium, 100 µg/L — 0.14***
***Chromium, 20 µg/L — 2.02***
***Nitrate, 45 mg/L — 0.11***
***Strontium-90, 8 pCi/L — 0.07***
***Trichloroethene, 5 µg/L — 0.02***
***Tritium, 20,000 pCi/L — 0.24***

The following descriptions of contaminants in the 100-K Area groundwater refer to conditions at wells that monitor the uppermost part of the unconfined aquifer. The 100-K Area contains only one well (199-K-32B) that is completed to monitor conditions below the upper aquifer; groundwater at this well is essentially free of contamination from past operations.

### 2.3.1.1 Chromium

Sodium dichromate was used in large quantities as a corrosion inhibitor at the KE and KW Reactors during their years of operation (1955 through 1971). The hexavalent form of chromium is soluble in water and is toxic to aquatic organisms and humans. The Washington State aquatic standard for hexavalent chromium is 10 µg/L, and the drinking water standard for total chromium is 100 µg/L. Chromium is a contaminant of concern for the 100-KR-4 Operable Unit interim action (EPA/ROD/R10-96/134) with a cleanup goal of 22 µg/L.

Figure 2.3-3 illustrates the extent of chromium contamination beneath the 100-K Area in FY 2008. The largest area of contamination is associated with the 116-K-2 Trench. A smaller plume with higher concentrations is downgradient of the KW Reactor building. Three wells near the KE Reactor building also have elevated chromium.

Chromium concentrations are elevated in some of the 100-K Area aquifer tubes. Figure 2.3-4 shows cross sections parallel to the river shore, with chromium concentrations at various depths in the aquifer tubes. Chromium concentrations in near-river monitoring wells are projected onto the cross section. At some tube sites, the chromium concentration is highest in the deepest tube (AT-K-3, AT-26). At other locations, the shallow or mid-depth tube has higher concentrations (AT-K-1, AT-K-5, and AT-K-6).

**Chromium near KW Reactor.** Chromium concentrations in a plume originating near KW Reactor exceed the drinking water standard in several wells (Figure 2.3-3). In early FY 2008, concentrations exceeded 3,000 µg/L in well 199-K-137, located south of the reactor building. Concentrations declined later in the year (Figure 2.3-5). The suspected source for this contamination is sodium dichromate in the vadose zone at unidentified locations. Candidate locations include the storage tank and transfer station at the southeastern side of the 183-KW Water Treatment Plant, and the underground piping used to add sodium dichromate to coolant water during operations. Chromium concentrations in well 199-K-107A were ~500 µg/L, but declined to 150 µg/L by the end of FY 2008 (Figure 2.3-5). Concentrations in three of the four extraction wells in the KW plume also were above the drinking water standard after well installation, but declined during FY 2007 and leveled off in FY 2008 (Figure 2.3-6). Currently well 199-K-139 is the only KW extraction well with concentrations above the drinking water standard. Excluding erroneous data, chromium concentrations in aquifer tubes downgradient of the KW plume typically are low (less than 10 µg/L).

***Chromium concentrations in a well south of KW Reactor building exceeded 3,000 µg/L, but declined in FY 2008.***

**Chromium near KE Reactor.** Three wells near the KE Reactor have chromium concentrations above background levels, while other wells have concentrations near detection limits. Well 199-K-36, near a former water treatment plant upgradient of the KE Reactor, had chromium concentrations exceeding 1,000 µg/L as recently as FY 2001. In FY 2008, concentrations ranged from 13 to 43 µg/L. Well 199-K-23, west of the KE Reactor building, had a concentration of 30 µg/L in FY 2008. Nearby wells had lower concentrations.

Well 199-K-141, downgradient of the KE Reactor, had chromium levels above the drinking water standard, with a maximum concentration of 400 µg/L. Chromium and specific conductance levels dropped abruptly in July 2008 (Figure 2.3-7). Nearby well 199-K-142 had chromium concentrations of less than 20 µg/L and low specific conductance since it was first sampled in FY 2007. The low specific conductance suggests the possibility of an unknown source of fresh water diluting groundwater near the wells.

The chromium contamination in well 199-K-141 does not appear to be connected to contamination in wells 199-K-36 and 199-K-23, because wells located between these locations have very low chromium levels. Well 199-K-32A, located farther downgradient of the KE Reactor, had low levels of chromium in FY 2008 (~11 µg/L filtered). Chromium usually is not detected at aquifer tube sites AT-18 and AT-K-2.

***Data from new wells along the 116-K-2 Trench helped define the chromium plume map. The pump-and-treat system in this region is being expanded.***

**Chromium Beneath the 116-K-2 Trench.** The plume originating at the 116-K-2 Trench is the largest in the area, but has relatively low concentrations (less than 200 µg/L; Figure 2.3-3). This trench received large volumes of reactor coolant water from 1955 to 1971. The trench plume is the target of interim remedial action, which was expanded in FY 2008 (Section 2.3.2). Groundwater extraction and injection have split the plume into two portions, with an area of clean groundwater near the middle of the trench.

Data from recently installed extraction and monitoring wells helped refine the plume map in FY 2008. Most of the new wells had chromium concentrations between 20 and 90 µg/L. Data from new wells 199-K-154 and 199-K-163 (east of the trench), show that an area of the plume with concentrations greater than 100 µg/L is larger than previously known. Chromium contamination east of the trench was pushed inland by radial flow around the large groundwater mound present during the operating years (HW-77170, *Status of the Ground Water Beneath Hanford Reactor Areas, January, 1962 to January, 1963*). The northern edge of the plume is delimited by new wells 199-K-159 and 199-K-160, which will be used for injection of treated water from the 100-KR-4 Pump-And-Treat System. They are located at the southern end of the 100-N Area. Chromium concentrations were less than 10 µg/L.

Chromium concentrations in wells between the 116-K-2 Trench and the river are typically less than the drinking water standard and appear to be stable or decreasing, with exceptions at several locations. The overall decrease in the level of contamination is a combined consequence of the pump-and-treat operation and dispersion. Figures 2.3-8 through 2.3-10 illustrate concentration trends for southwestern, central, and northeastern groups of wells, respectively.

At the southwestern edge of the plume, well 199-K-18 presents an exception to the generally decreasing trends. Concentrations have been increasing, with a maximum FY 2008 value of 168 µg/L (Figure 2.3-8). The start of the increasing trend at this location correlates with the start of the pump-and-treat system in October 1997, indicating a relationship to the changes in groundwater flow patterns because of groundwater extraction and injection. Chromium concentrations also are relatively high at nearby aquifer tube site AT-K-3 (81 µg/L in the deep tube in FY 2008).

In the central portion of the plume, chromium levels have declined by an order of magnitude in extraction well 199-K-125A and in well 199-K-117A (Figure 2.3-9). Levels remained above the drinking water standard in well 199-K-22 (near the trench) and fluctuated seasonally in extraction well 199-K-114A (near the river). Aquifer tubes monitoring the central portion of the trench show decreasing chromium trends. The decline may be a result of the effects of the pump-and-treat system (Section 2.3.2.2).

At the northeastern end of the trench, chromium concentrations are declining in monitoring wells (Figure 2.3-10). However, aquifer tube AT-26 has had increasing chromium concentrations since FY 2002, with a maximum of 64 µg/L in November 2007. Levels decreased in May and August 2008 (Figure 2.3-11). The overall increase may indicate northward migration of the plume.

### 2.3.1.2 Tritium

***Tritium forms three plumes in the 100-K Area.***

Tritium was common in liquid effluent discharged to the ground during 100-K Reactor operations. However, some of the tritium currently observed in groundwater was introduced after the shutdown of the reactors in 1971. Current sources and potential sources for providing tritium to groundwater include loss of shielding water from the KE and KW Basins, the soil columns beneath the former gas condensate cribs located to the east of each reactor building, and possibly irradiated materials contained in the 118-K-1 Burial Ground. The drinking water standard for tritium is 20,000 pCi/L.

Figure 2.3-12 shows the distribution of tritium in groundwater beneath the 100-K Area. Few wells had average concentrations above the drinking water standard

in FY 2008. Some of the highest tritium concentrations are immediately downgradient of the 116-KE-1 and 116-KW-1 Cribs. During operating years, the cribs received liquid effluent containing high concentrations of tritium and carbon-14. These waste sites were excavated and backfilled with clean material during FY 2004. Some contaminated soil remained at the bottom of the excavations.

Because high concentrations of tritium are present in the shielding water of each fuel storage basin, groundwater is monitored for evidence of shielding water loss to the ground (PNNL-14033, *Groundwater Monitoring and Assessment Plan for the 100-K Area Fuel Storage Basins*). Also, tritium from materials in the 100-K Burial Ground may be impacting groundwater in the area north of the burial ground.

**Tritium near KW Reactor.** The plume near the KW Reactor is most likely associated with effluent disposed during the operating years to the former 116-KW-1 Condensate Crib. In FY 2008, the highest concentration was 210,000 pCi/L in well 199-K-106A, located downgradient of the crib. This was the only KW well in which the tritium concentration exceeded the drinking water standard. An unexplained increase in tritium concentrations at well 199-K-106A began in 2001, peaked sharply in 2003 and early 2005, and subsequently declined (Figure 2.3-13). Other constituents showing a similar trend include specific conductance, anions (including nitrate), and technetium-99. Carbon-14, which was disposed to the crib but is less mobile than tritium, does not follow the tritium trend. The cause for the trend at well 199-K-106A is presumed to be mobilization of contaminants associated with the crib and underlying soil column, although a driving mechanism has not been identified.

There is no evidence in groundwater monitoring data to suggest water loss to the ground from the KW Basin in recent years. Wells 199-K-34 and 199-K-107A are most likely to detect shielding water. The maximum FY 2008 tritium concentrations were 2,800 pCi/L in well 199-K-34 and 910 pCi/L in well 199-K-107A.

Aquifer tubes downgradient of the KW Reactor have low tritium concentrations, ranging from below detection limits to 640 pCi/L in FY 2008.

**Tritium near KE Reactor.** The KE tritium plume was formed from past disposal to the former 116-KE-1 Condensate Crib, leaks to the ground from KE Basin (1976 to 1979, and again in 1993), and possibly mobilization of contamination from the vadose zone beneath the 116-KE-3 Drain Field and associated catch tank. The tritium distribution pattern reflects a coalescing of plumes from these sources.

Only one well near the reactor building had tritium concentrations above the drinking water standard in FY 2008. Figure 2.3-14 shows concentration trends for tritium and co-contaminant carbon-14 at well 199-K-30. Tritium concentrations in FY 2008 ranged from 88,600 to 410,000 pCi/L, about the same as the previous five years.

The leading edge of the tritium plume created by the 1993 leak from the KE Basin is believed to have reached the Columbia River. In 1994, concentrations peaked in well 199-K-27, near the basins (Figure 2.3-15). Concentrations in well 199-K-32A, located 280 m downgradient, peaked in 2001 at a much lower level. The estimated groundwater velocity based on movement of the tritium peak is 40 m/year. At this velocity, the 1994 tritium peak would have been expected to reach the river (540 m from well 199-K-27) in FY 2008. However, aquifer tube sites AT-18, T-K-2, and SK-068 continued to show only low levels of tritium (hundreds of picocuries per liter) in FY 2008.

*The highest tritium concentrations were in two new wells installed near the southern end of the 116-K-2 Trench. The concentrations in the new wells were about ten times higher than in nearby wells.*

Increases in tritium concentrations in well 199-K-27 and other wells near KE Reactor that started in early 2003 (Figure 2.3-15) remain unexplained. There was no evidence from facility operations suggesting a significant loss of shielding water. The 2003 tritium peak in well 199-K-27 has not reached downgradient well 199-K-32A. Well 199-K-27 and nearby well 199-K-109A were decommissioned in FY 2008.

**Tritium near the 118-K-1 Burial Ground and 116-K-2 Trench.** A third region of tritium at levels above the drinking water standard is near the southern end of the 116-K-2 Trench, downgradient of the 118-K-1 Burial Ground (Figure 2.3-12). At the northwestern corner of the burial ground, tritium concentrations at well 199-K-111A began rising abruptly in mid-2000 to a peak value of 98,200 pCi/L in April 2002. Since that time, concentrations declined to a level of less than 10,000 pCi/L. The source for tritium in groundwater near the burial ground was the subject of a multifaceted investigation during 2002 and 2003 (PNNL-14031). Results suggested the likelihood of a tritium source in the burial ground, along with an underlying groundwater plume.

Several wells at the southern end of the 116-K-2 Trench had tritium concentrations above the drinking water standard in FY 2008. The plume, as previously defined, had concentrations between 20,000 and 40,000 pCi/L. However, two new wells in this region had much higher levels in FY 2008.

- Well 199-K-144 had a tritium concentration of 286,000 pCi/L in April 2008. The sample was reanalyzed and the result was confirmed. A sample from early FY 2009 had a tritium concentration of 200,000 pCi/L.
- Well 199-K-157 was sampled three times in FY 2008, and tritium concentrations varied: 621,000 pCi/L in May; 21,000 pCi/L in July; and 620,000 pCi/L in September.

The tritium source for the wells is uncertain; it may represent past disposal to the 116-KE-1 Crib or 116-K-2 Trench, or tritium from a source farther inland, such as the 118-K-1 Burial Ground.

### 2.3.1.3 Carbon-14

Condensate from gas circulated through the KE and KW Reactors contained carbon-14 (along with tritium) and was discharged to infiltration cribs at the east side of each reactor building. Release of carbon-14 from the cribs, which were excavated and backfilled during FY 2004, is the source for the carbon-14 plumes near each reactor. The drinking water standard (2,000 pCi/L) continued to be exceeded during FY 2008 at several wells that monitor these plumes. The half-life for carbon-14 is 5,730 years. This radionuclide exchanges with carbon in carbonate minerals, so its movement is more restricted and variable than a nonexchanging constituent like tritium.

*Carbon-14 forms two small plumes with sources near the KE and KW Reactors. Levels have declined over time.*

The two plumes are positioned between the crib source locations and the Columbia River. The KW plume is larger than the KE plume, extending downgradient to well 199-K-132. Concentrations in wells near the source area (i.e., well 199-K-106A) have declined in the past 10 years (Figure 2.3-16).

Carbon-14 concentrations also exceeded the drinking water standard in some samples from wells southwest of the 116-KW-1 Crib (Figure 2.3-17). Concentrations exceeded the drinking water standard in the 1990s in well 199-K-108A. During

the period 2000 to 2004, groundwater at this location was diluted by clean water from an unknown source, and contamination indicators were dramatically reduced in concentration. In 2005, dilution by clean water stopped, and monitoring results began to return to previous levels. Since FY 2006, carbon-14 concentrations in this well have been near the drinking water standard (FY 2008 averaged 1,700 pCi/L). New well 199-K-137 also had some FY 2008 results above the standard.

Aquifer tube AT-17-D, downgradient of the KW Reactor, typically detects concentrations of carbon-14 in the hundreds of picocuries per liter, which are above background levels.

The KE carbon-14 plume only exceeded the standard in two wells (199-K-29 and 199-K-30). Concentrations have declined in the past 10 years (Figure 2.3-14). Aquifer tubes downgradient of the KE plume show carbon-14 near detection limits.

### 2.3.1.4 Strontium-90

In the 100-K Area, strontium-90 concentrations exceed the 8 pCi/L drinking water standard in wells near KW Reactor, KE Reactor, and the 116-K-2 Trench. Strontium-90 primarily was released to the environment at 100-K Area via used reactor coolant. It also may have been present in fuel storage basin shielding water, which was discharged to nearby drain fields and injection wells during the reactor operating period. The radionuclide is moderately mobile in the environment and has a half-life of ~29 years.

**Strontium-90 near the KW Reactor.** Strontium-90 concentrations exceeded the drinking water standard in wells 199-K-34 and 199-K-107A near the KW Reactor. The maximum concentration in FY 2008 was 37.3 pCi/L in well 199-K-34, an increase from the previous few years. Analytical results from downgradient extraction wells 199-K-139 and 199-K-140 ranged from undetected to 3.4 pCi/L.

***The highest strontium-90 concentrations are in a well near the northwest corner of the KE Reactor.***

**Strontium-90 near the KE Reactor.** The highest concentrations in 100-K Area groundwater have been observed at well 199-K-109A near the northwestern corner of the KE Reactor. The peak in strontium-90 concentrations in the mid-1990s corresponded to a period of higher water levels. Strontium-90 concentrations continued to fluctuate in this well and averaged over 1,000 pCi/L (the derived concentration guide) in FY 2008. Nearby wells have concentrations near or below the detection limit. The presumed source is contamination in the vadose zone beneath the former drain field/injection well.

**Strontium-90 near the 116-K-2 Trench.** The effluent disposed to the trench contained strontium-90, which is detected at relatively low levels in a few scattered wells. The highest concentration was 32.5 pCi/L in well 199-K-21, downgradient of the central portion of the trench. Concentrations are declining gradually.

In FY 2008, the maximum concentration of strontium-90 in 100-K Area aquifer tubes was 1.77 pCi/L in AT-19-M.

### 2.3.1.5 Nitrate

Nitrate is widely distributed beneath the 100-K Area, mostly at levels below the 45 mg/L drinking water standard. Potential sources include currently active septic systems and past-practice waste sites, but the distribution pattern and trends do not clearly indicate specific sources. Three wells near the KW Reactor (199-K-34, 199-K-106A, and 199-K-108A) and three wells near the KE Reactor (199-K-11, 199-K-23, and 199-K-30) had concentrations above the drinking water standard.

The highest concentration in FY 2008 was 139 mg/L in well 199-K-106A, located near KW Reactor. At the southern end of the 116-K-2 Trench, well 199-K-18 also had concentrations exceeding the standard.

Northeast of the 116-K-2 Trench, new well 199-K-159 had a nitrate concentration of 58.9 mg/L. This well is located in the southern part of the 100-N Area and may relate to nitrate contamination there (Section 2.4).

#### 2.3.1.6 Trichloroethene

Samples from wells 199-K-106A and 199-K-132, located downgradient of the former 116-KW-1 Condensate Crib, routinely are monitored for trichloroethene. In well 199-K-106A, located nearest the crib, levels have declined from ~30 µg/L in the mid-1990s to 4.6 µg/L in FY 2008. Extraction well 199-K-132, located farther downgradient, had a concentration of 7.7 µg/L in FY 2008, an increase from the previous year. The drinking water standard for trichloroethene is 5 µg/L.

### 2.3.2 Operable Unit Activities

This section summarizes the status of CERCLA five-year review action items and interim remedial action in the 100-KR-4 Operable Unit.

***The remedial action objectives for the 100-KR-4 Operable Unit (EPA/ROD/R10-96/134) are as follows.***

- ***Protect aquatic receptors in the river bottom from contaminants in groundwater entering the Columbia River.***
- ***Protect human health by preventing exposure to contaminants in the groundwater.***
- ***Provide information that will lead to the final remedy.***

***The contaminant of concern is hexavalent chromium. The record of decision specifies 22 µg/L as the concentration at compliance wells that is protective of aquatic organisms in the river environment.***

Interim remedial action under CERCLA at the 100-KR-4 Operable Unit initially targeted the chromium plume beneath the 116-K-2 Trench. A pump-and-treat system removes hexavalent chromium from extracted groundwater and injects the treated effluent upgradient of the former trench (Figure 2.3-1). The system began operating in October 1997. An expansion to this system was under construction during FY 2008 to provide additional treatment capacity in the vicinity of the 116-K-2 Trench. A second area of contamination, near the KW Reactor complex, was added to the interim remedial action, and a pump-and-treat system began to operate in FY 2007. The remedial action objectives and criteria for success remain the same as for the initial target plume.

As described in DOE/RL-96-84, *Remedial Design and Remedial Action Work Plan for 100-HR-3 And 100-KR-4 Groundwater Operable Units' Interim Action*, the performance criteria for these pump-and-treat systems include achieving hexavalent chromium concentrations that do not exceed 22 µg/L in near-river wells.

#### 2.3.2.1 Status of CERCLA Five-Year Review Action Items

The second CERCLA five-year review was published in November 2006 (DOE/RL-2006-20). The review identified four actions pertaining to the 100-K Area.

- **Action 3-1.** Install three additional wells to further delineate the 116-K-2 Trench chromium plume (August 2008). Wells 199-K-153, 199-K-154, and 199-K-163 were installed to complete this action.

- **Action 4-1.** Construct a new pump-and-treat facility to address the chromium groundwater plume in the KW Reactor area (August 2008). The KW Pump-and-Treat System began operating in January 2007. Section 2.3.2.3 provides more information.
- **Action 5-1.** Expand the 100-KR-4 Pump-and-Treat System by 378.5 L/min to enhance remediation of the plume between the 116-K-2 Trench and the N Reactor perimeter fence (August 2008). Construction of a 2,271 L/min system was completed in September 2008. It will begin to operate in FY 2009.
- **Action 5-2.** Add wells between the 116-K-2 Trench and the N Reactor perimeter fence for groundwater extraction, and connect the additional wells to the pump-and-treat system (March 2007). Wells 199-K-130, 199-K-131, 199-K-147, 199-K-148, and 199-K-149 were installed and will be connected to the expanded pump-and-treat system.

***The DOE expanded the 100-KR-4 Pump-and-Treat System in FY 2008. New extraction wells will begin to operate in FY 2009.***

### 2.3.2.2 116-K-2 Trench Pump-and-Treat System

The original 100-KR-4 Pump-and-Treat System, which remediates groundwater around the 116-K-2 Trench, has been operating since 1997. The DOE expanded the pump-and-treat system in FY 2008 to fulfill five-year review action items 5-1 and 5-2. Twenty-three new wells were installed as part of this expansion (Chapter 4.0). The new extraction and injection wells will begin operating in FY 2009. DOE/RL-2006-75, *Supplement to the 100-HR-3 and 100-KR-4 Remedial Design Report and Remedial Action Workplan for the Expansion of the 100-KR-4 Pump and Treat System*, describes the design of the expansion and monitoring requirements. In FY 2008, two wells were sampled less frequently than planned (Appendix A). Two monthly samples were missed in well 199-K-18 and one monthly sample was missed in well 199-K-20 because of conflicts in scheduling field staff.

DOE/RL-2008-05, *Calendar Year 2007 Annual Summary Report for the 100-HR-3, 100-KR-4, and 100-NR-2 Operable Unit Pump-and-Treat Operation*, presents results of operational monitoring and additional details about the pump-and-treat systems for calendar year 2007. Results for calendar year 2008 will be included in an upcoming report on the 100 Area Pump-and-Treat Systems. Appendix A includes lists of sampling frequencies and analyses.

During FY 2008, the pump-and-treat system at the 116-K-2 Trench involved nine extraction wells, five injection wells, and an ion-exchange resin treatment system. The system treated 502 million liters of groundwater and removed 17.9 kg of chromium. Since the startup of operations in October 1997, the system has treated ~4.65 billion liters of groundwater and removed ~330 kg of chromium.

Chromium concentrations within the target plume area show generally decreasing or stable trends (Section 2.3.1.1 and Figures 2.3-8 through 2.3-10). Of the 16 wells monitored for compliance[1] in FY 2008 (Appendix A), only wells 199-K-117A and 199-K-20 had concentrations consistently at or below the remedial action goal.

***Two pump-and-treat systems have removed 361 kg of chromium from 100-K Area groundwater.***

### 2.3.2.3 KW Pump-and-Treat System

The DOE began to operate a pump-and-treat system for the chromium plume (Section 2.3.1.1) near the KW Reactor in January 2007. DOE/RL-2006-52, *The*

1 Certain monitoring wells are designated as "compliance wells" in the interim action record of decision. Chromium concentrations in samples from these wells are compared to the remediation goal (22 µg/L) to determine if the remedial action is effective.

*KW Pump and Treat System Remedial Design and Remedial Action Work Plan, Supplement to the 100-KR-4 Groundwater Operable Unit Interim Action*, describes the system. In FY 2008, the system included four extraction wells, two injection wells, and ion-exchange treatment equipment similar to that previously used in the 100-KR-4 and 100-HR-3 Operable Units. Initial treatment capacity was 379 L/min.

Plans are underway to increase the KW Pump-and-Treat System treatment capacity to 757 L/min by September 2009. A second 379 L/min treatment train will be added to the existing system. Four new wells were drilled in August and September 2008 around the KW Reactor, three of which will be converted to extraction wells. Chromium concentrations in these four wells were greater than 50 μg/L, so none can be used for injection. One new well, 199-K-165 (Figure 2.3-1), had chromium at concentrations up to 3,020 μg/L during initial sampling in August 2008. This well expands the high-concentration part of the plume towards the south. To aid injection, two new wells will be drilled upgradient of the current plume in FY 2009.

In FY 2008, the KW Pump-and-Treat System extracted 197 million liters of water and removed 15.3 kg of hexavalent chromium. Since startup, the system has treated 320 million liters of water and removed 31.1 kg of chromium.

By the end of FY 2008, hexavalent chromium concentrations in near-river extraction wells 199-K-132 and 199-K-138 were ~40 μg/L (Figure 2.3-6). Concentrations declined in inland extraction well 199-K-139 (between 100 and 150 μg/L), and were stable at ~25 μg/L in inland extraction well 199-K-140. Upgradient monitoring well 199-K-137 had much higher chromium concentrations (Figure 2.3-5). Well 199-K-137 and other wells in the more highly concentrated portion of the plume will be connected to the expanded KW Pump-And-Treat System during FY 2009.

### 2.3.2.4 Calcium Polysulfide Treatability Test

This test, initiated in 2005, evaluated the practicality of treating chromium in the groundwater as an alternative to pump-and-treat systems. The study concluded that hexavalent chromium effectively was eliminated from the treated portion of the aquifer (DOE/RL-2006-17, *Treatability Test Report for Calcium Polysulfide in the 100-K Area*). The aquifer was chemically reduced and was expected to remain a permeable reactive barrier that will treat groundwater as it flows through.

Four wells adjacent to polysulfide injection well 199-K-126 were sampled twice in FY 2008. Chromium concentrations in well 199-K-126 were 30 to 46 μg/L. Surrounding wells had no detectable chromium, with one exception. Well 199-K-136 had a chromium result of 682 μg/L in November 2007 and was not detected in May 2008. The high value is flagged as an error, as it is much higher than concentrations in the surrounding plume.

Total organic carbon increased in the test site monitoring wells in FY 2008, with a maximum of over 400 mg/L in well 199-K-134. This is a residual effect from the test, when vegetable oil was injected to stimulate bacterial growth to moderate sulfate levels. Groundwater samplers observed oil in the water when they sampled the wells.

## 2.3.3 Facility Monitoring — KE and KW Basins

### *D. G. Horton*

The fuel storage basins located within the KE and KW Reactor buildings were used from the late 1970s to 2004 to store irradiated fuel from the 100-N Reactor, along with other miscellaneous fuel recovered during remedial actions at other reactor areas. Each basin holds ~4.9 million liters of shielding water that is highly contaminated with long-lived radionuclides, some of which are mobile in the environment (e.g., tritium, strontium-90). Leaks at the KE Basin have affected groundwater. The vadose zone beneath the basin also is known to contain radionuclides that are absorbed onto the soil. Tri-Party Agreement (Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order*) Milestone M-34-00 covers the fuel removal and basin cleanup project, the latter now referred to as the K Basins Closure Project.

More information on K Basins cleanup and demolition is available at http://www.hanford.gov/rl/?page=220&parent=0.

During FY 2008, all shielding water was removed from the KE Basin and the basin was filled with a sand-grout mixture. The sand-like material provides shielding from contamination embedded in the basin's walls, as well as a platform for heavy machinery to drive on as the superstructure is demolished. Demolition of the superstructure began in FY 2008.

The KE and KW Basins sampling and analysis schedule complements other schedules associated with the 100-KR-4 Operable Unit. The monitoring plan for KE and KW Basins (PNNL-14033) describes the following objectives for the monitoring.

- Characterize groundwater conditions between KE and KW Basins and the Columbia River to provide a periodic status of current conditions and the attenuation of plumes.
- Distinguish basin-related groundwater contamination from other contamination to help guide operational and remedial action decisions.
- Maintain a strategy for the potential expansion of monitoring capabilities to respond to future basin-related issues.

These objectives were valid as long as shielding water remained in the basins. Now that the shielding water has been removed from the KE Basin and demolition of the basin has begun, the strategy and objectives for groundwater monitoring need to be reviewed. This work is planned for FY 2009.

***Shielding water has been removed from the KE Basin and demolition of the basin has begun. The strategy and objectives for groundwater monitoring need to be reviewed.***

The primary indicator for detecting shielding water in groundwater is tritium, which is present at concentrations in the millions of picocuries-per-liter at the KW Basin. Before demolition began, the KE Basins water had similar concentrations. Other less mobile radionuclides (e.g., strontium-90, cesium-137) also are present at relatively high concentrations in shielding water. However, if small volumes or low rates of leaks were to occur, the strontium-90 and cesium-137 might not reach groundwater because they would be retained in the vadose zone, and tritium levels might be too low to detect. One additional tracer for shielding water is technetium-99, which is mobile (like tritium), but is at relatively low concentrations in the shielding water.

Wells 199-K-27 and 199-K-109A were located adjacent to the KE Basin in a position most likely to detect basin leaks. Both of these wells were decommissioned

in May 2008 in preparation for demolishing the KE Basin. Decommissioning of these wells was anticipated and replacement wells 199-K-141 and 199-K-142 were drilled further downgradient in FY 2007. During FY 2008, tritium concentrations remained relatively constant at levels below the drinking water standard in all four wells, although the concentration increased in well 199-K-109A from 3,000 pCi/L during FY 2007 to 9,600 pCi/L during FY 2008 (Section 2.3.1.2 and Figure 2.3-18). The average annual tritium concentration decreased in well 199-K-27 from 6,800 pCi/L during FY 2007 to 3,800 pCi/L during FY 2008. There is still no clear source to explain the abrupt increase in concentrations that started in January 2003 at these wells. There has been no unexplained loss of water from the basin to account for the trend changes in groundwater.

Near the KW Reactor, tritium concentrations at well 199-K-106A, located downgradient of the former 116-KW-1 Condensate Crib began to rise in 2001 and spiked in mid-2003 and 2005 to over 1 million pCi/L (Figure 2.3-13). Levels declined in FY 2006 and 2007 and have remained relatively constant since January 2008. The likely source for the tritium is the vadose zone beneath the former crib and not related to potential water loss from the KW Basin.

The annual average concentration of strontium-90 exceeded the drinking water standard (8 pCi/L) in two wells monitoring the KW Reactor area and one well monitoring the KE Reactor area (Section 2.3.1.4). The highest concentrations were in the KE Reactor area where strontium-90 averaged 1,100 pCi/L in well 199-K-109A prior to decommissioning in May 2008. This was up substantially from 480 pCi/L during FY 2007, but similar to an average of 1,200 pCi/L during FY 2006. Wells 199-K-34 and 199-K-107A, located in KW Reactor area, averaged 37 and 24 pCi/L in FY 2008.

***Groundwater monitoring in the 100-KR-4 groundwater interest area includes the following activities.***

***CERCLA Long-Term Monitoring (Appendix A)***

- ***Thirty-three wells are scheduled for monthly to biennial sampling. All wells were sampled as planned.***

***CERCLA Interim Action Monitoring (Appendix A)***

- ***Twenty-eight wells are scheduled for monthly to annual sampling. Two wells were not sampled as frequently as planned in FY 2008.***
- ***The DOE installed 27 new wells to support pump-and-treat activities and 29 new aquifer tubes to help define plumes.***

***Facility Monitoring (Appendix B)***

- ***Fourteen wells are scheduled for quarterly to semiannual sampling to detect potential shielding water loss to the ground from the KW and KE Basins. The wells were sampled as planned.***
- ***Four wells are scheduled for monthly sampling during basin cleanout. One monthly sample was not collected.***
- ***Two of the wells were decommissioned for basin decommissioning.***

**Figure 2.3-1. Facilities and Groundwater Monitoring Wells in the 100-K Area.**

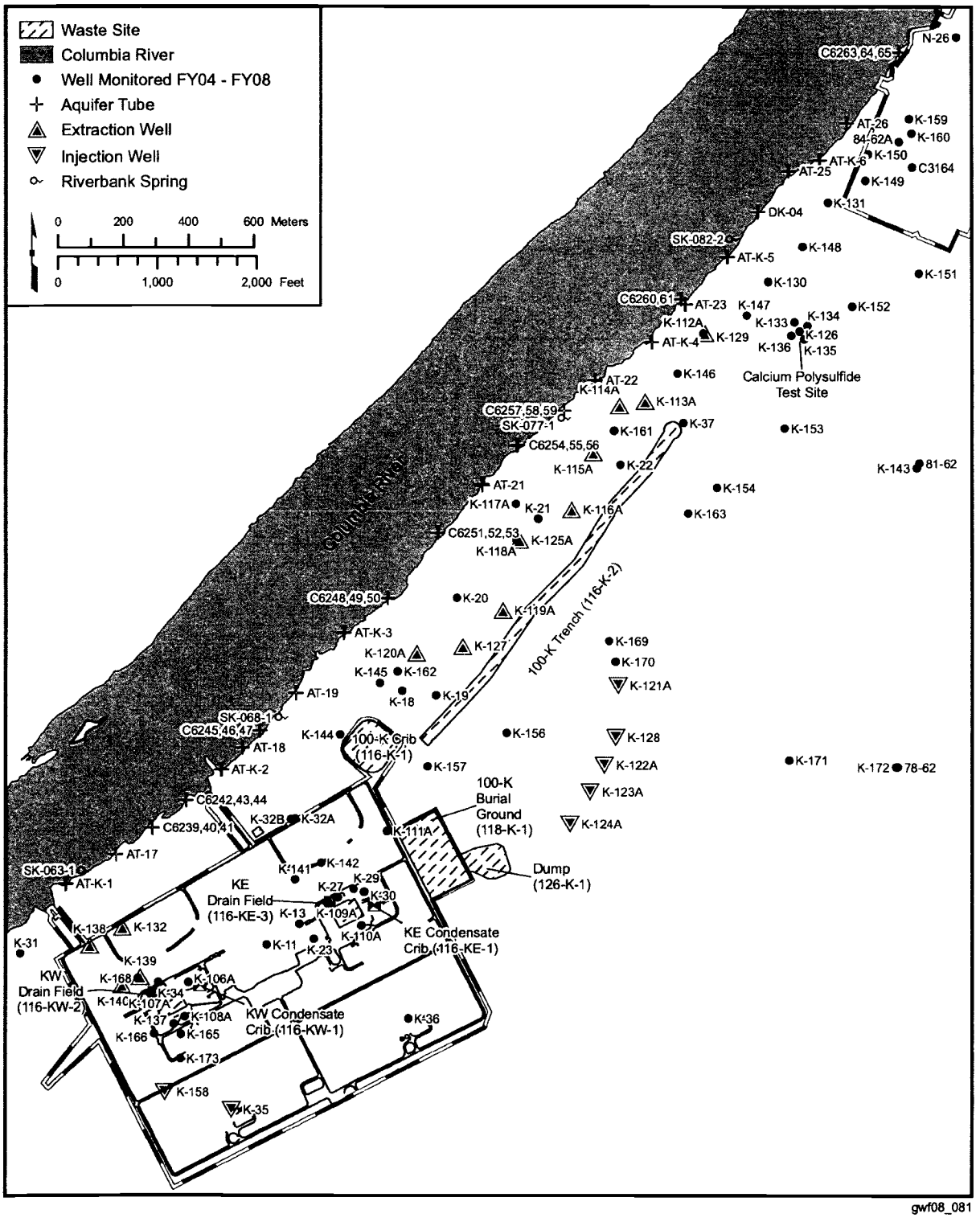


**Figure 2.3-2. 100-K Area Water-Table Map, March 2008.**

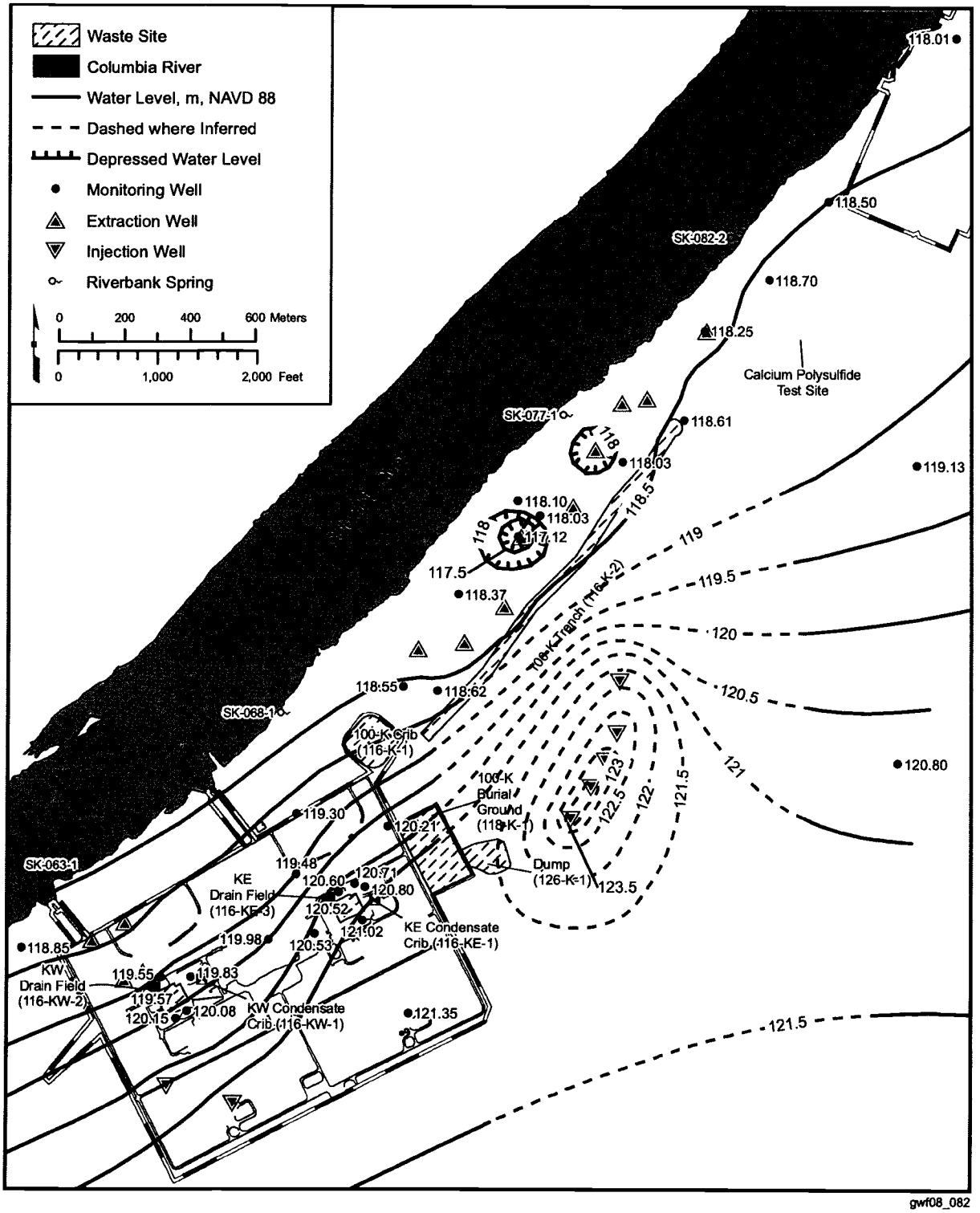


**Figure 2.3-3. Average Chromium Concentrations in the 100-K Area, Upper Part of Unconfined Aquifer.**

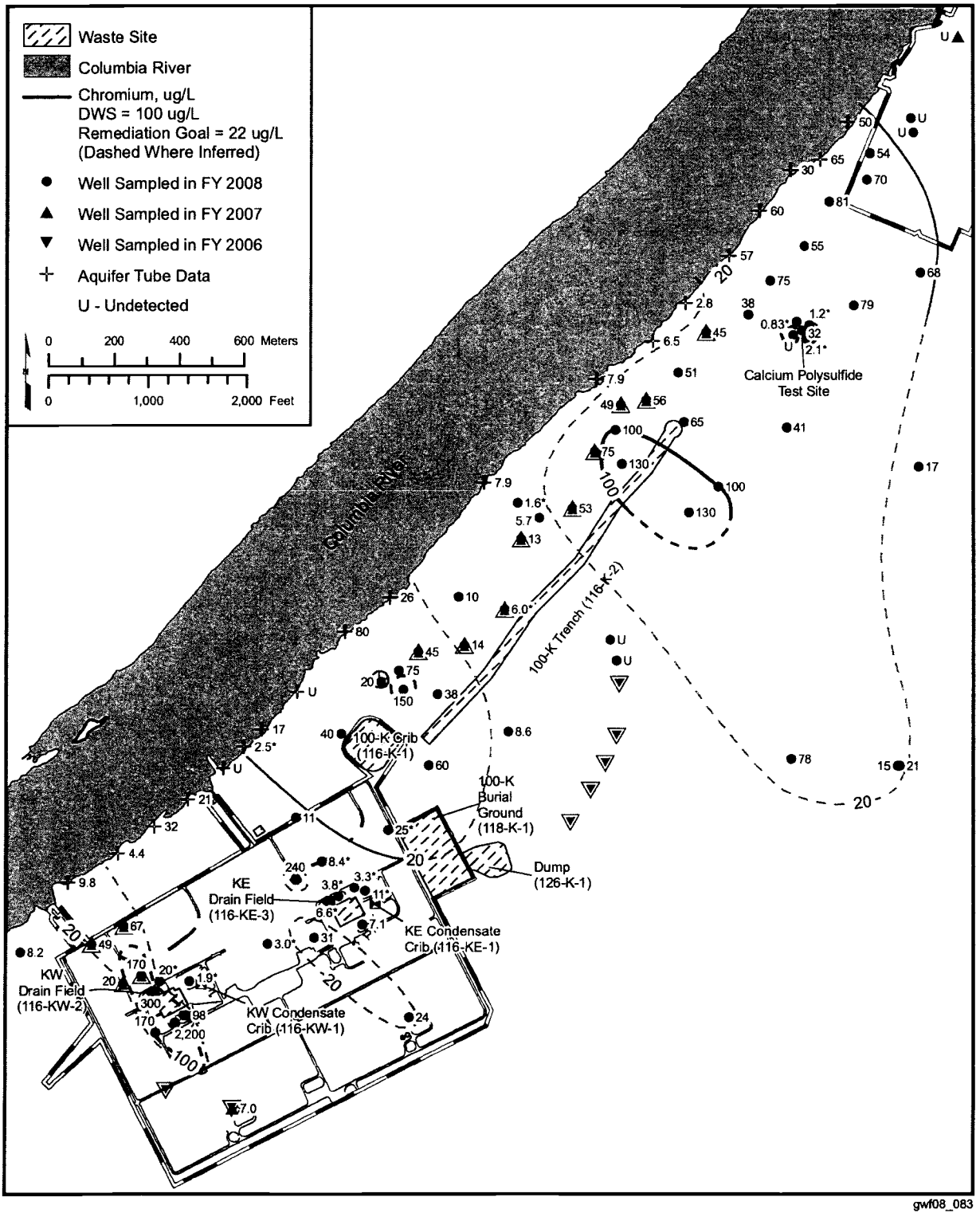
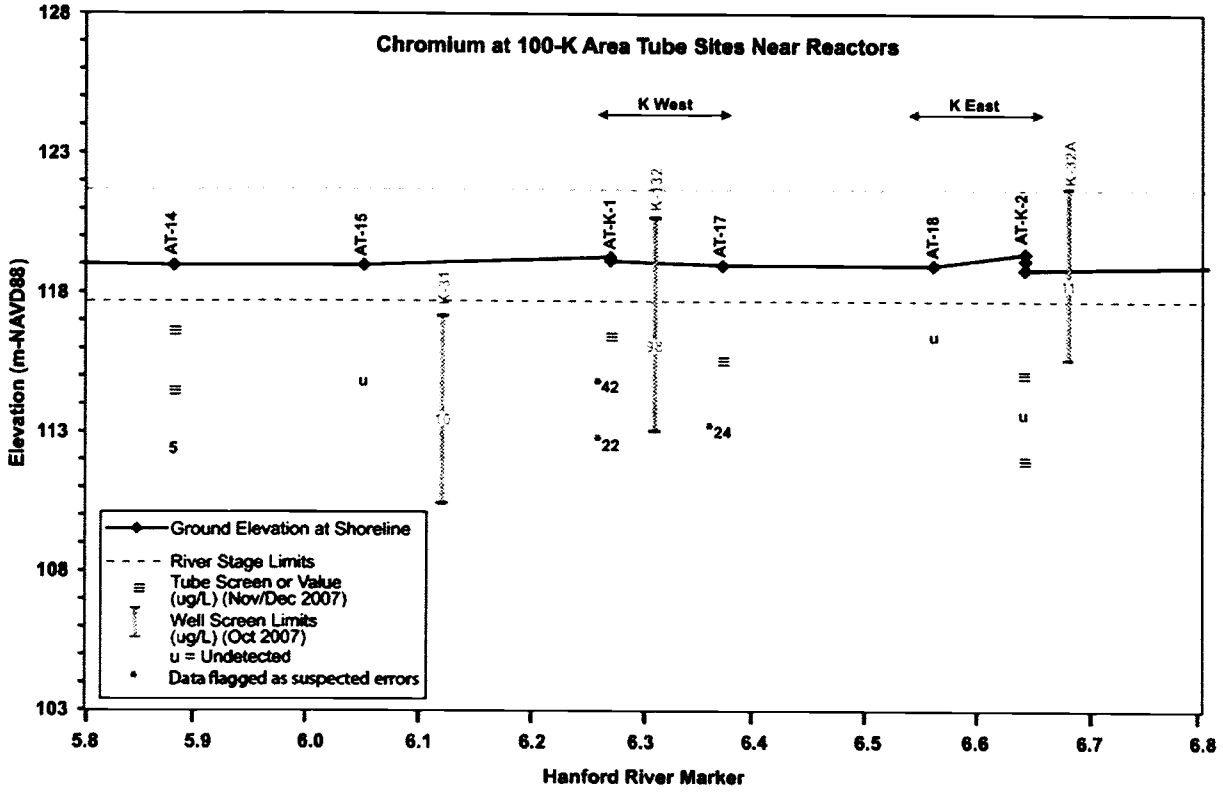


**Figure 2.3-4. Cross Section of Chromium Concentrations and Screen Elevations in Wells and Aquifer Tubes in the 100-K Area.**



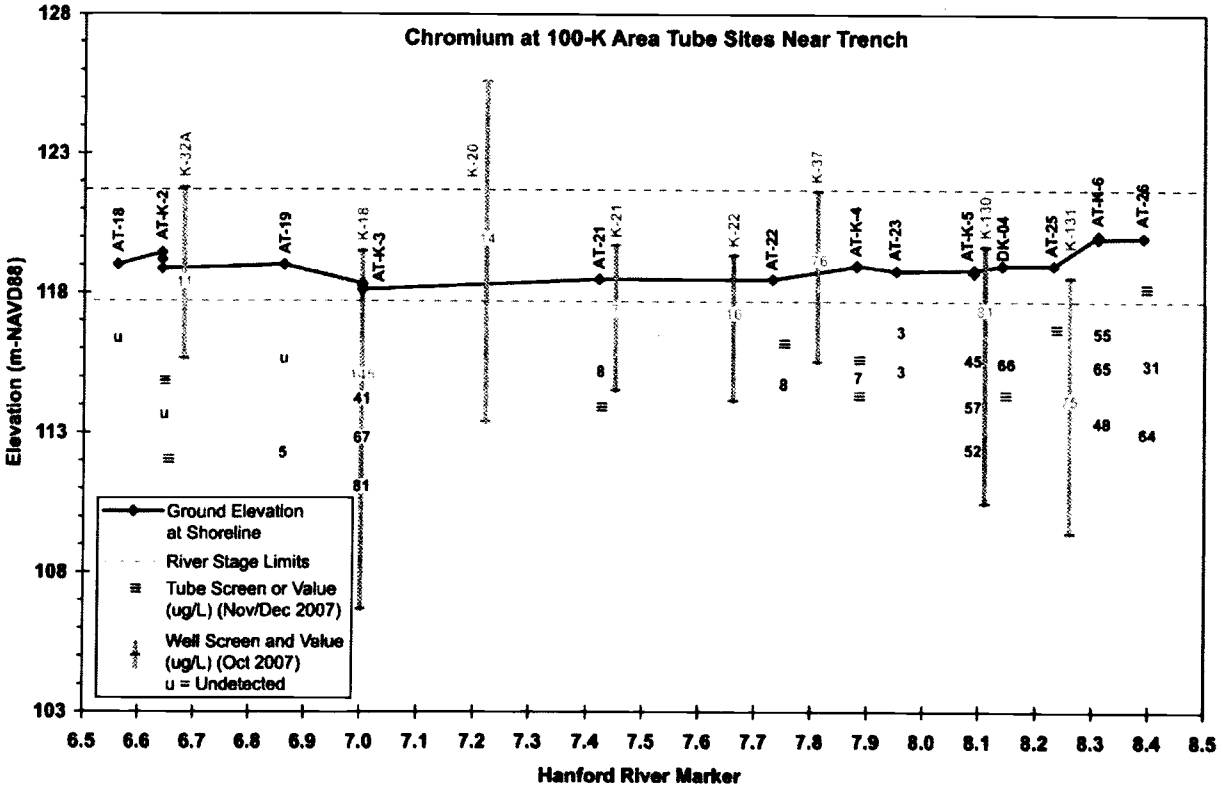




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**Figure 2.3-5. Chromium Concentrations in KW Monitoring Wells.**

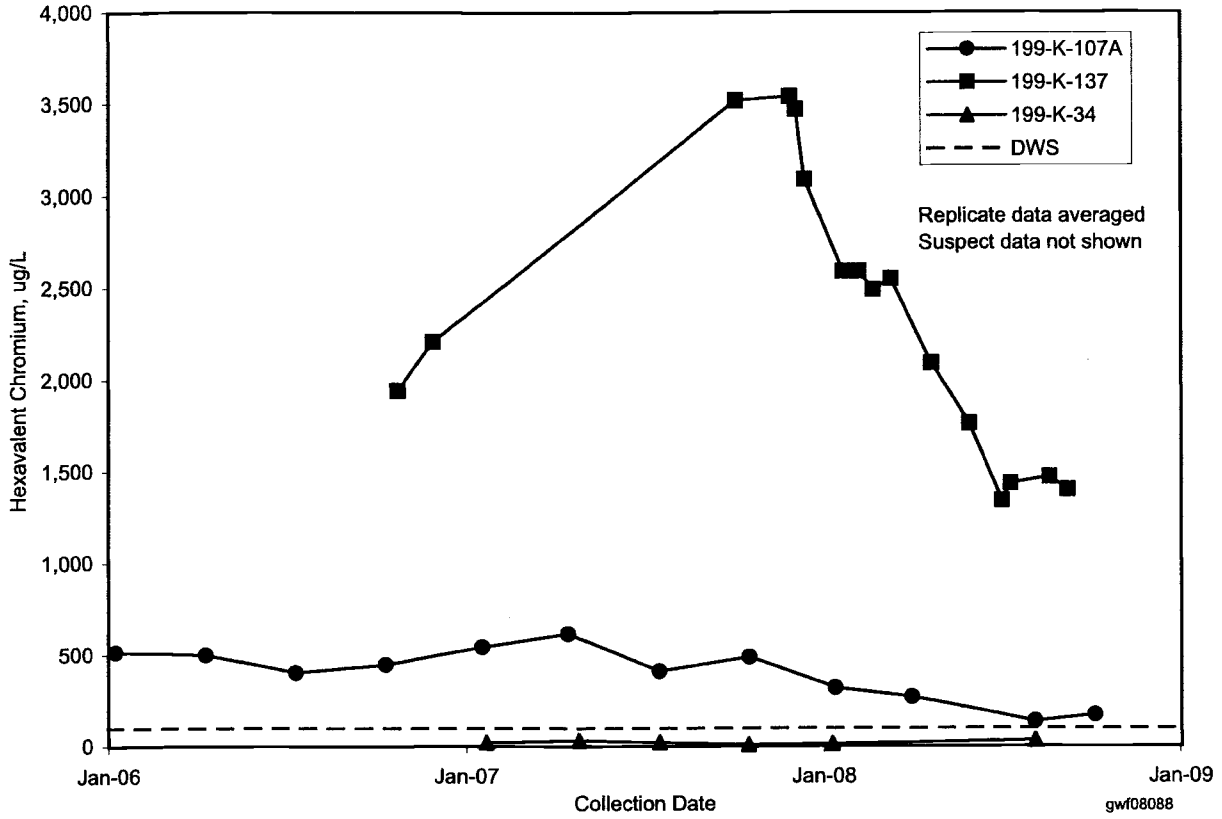



**Figure 2.3-6. Chromium Concentrations in KW Extraction Wells.**

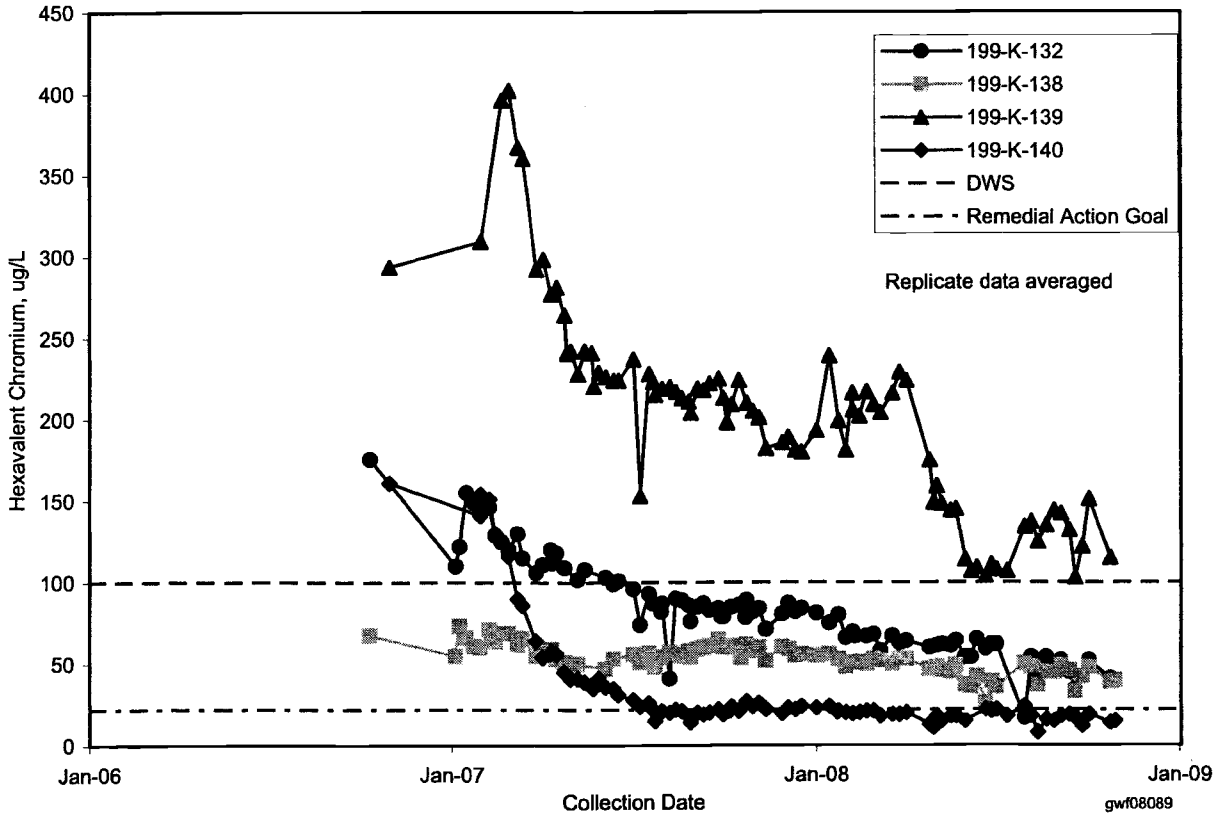
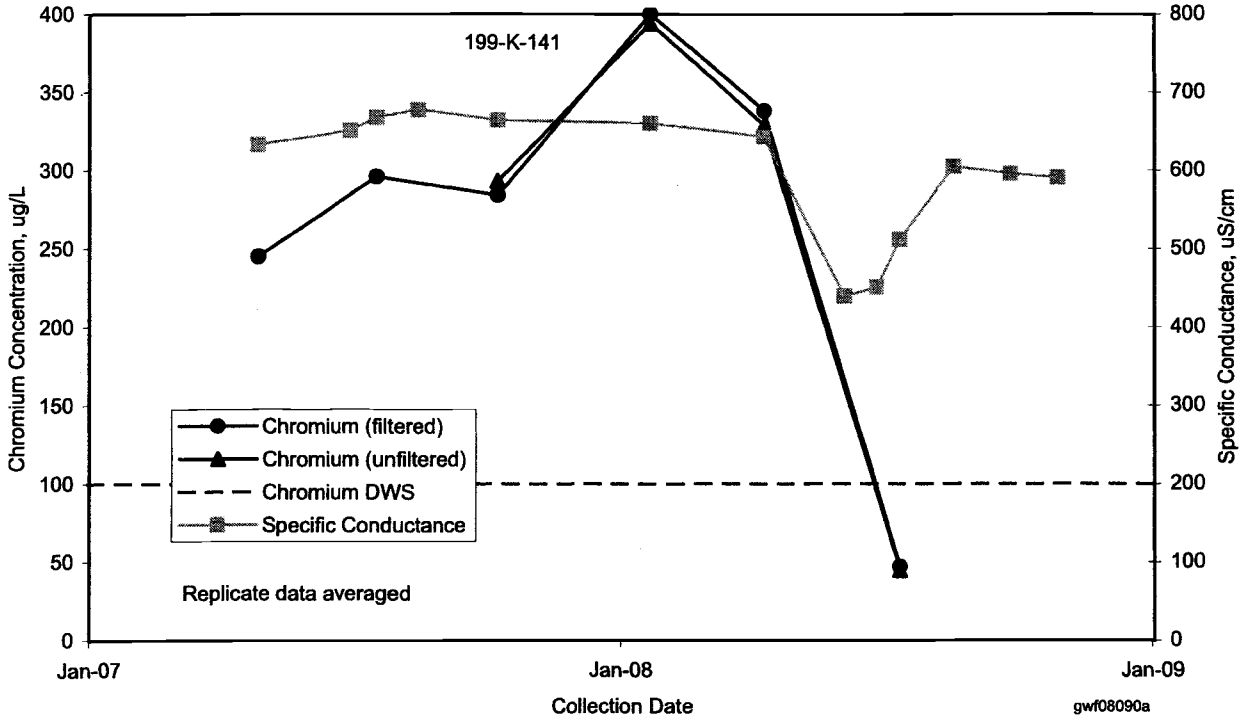
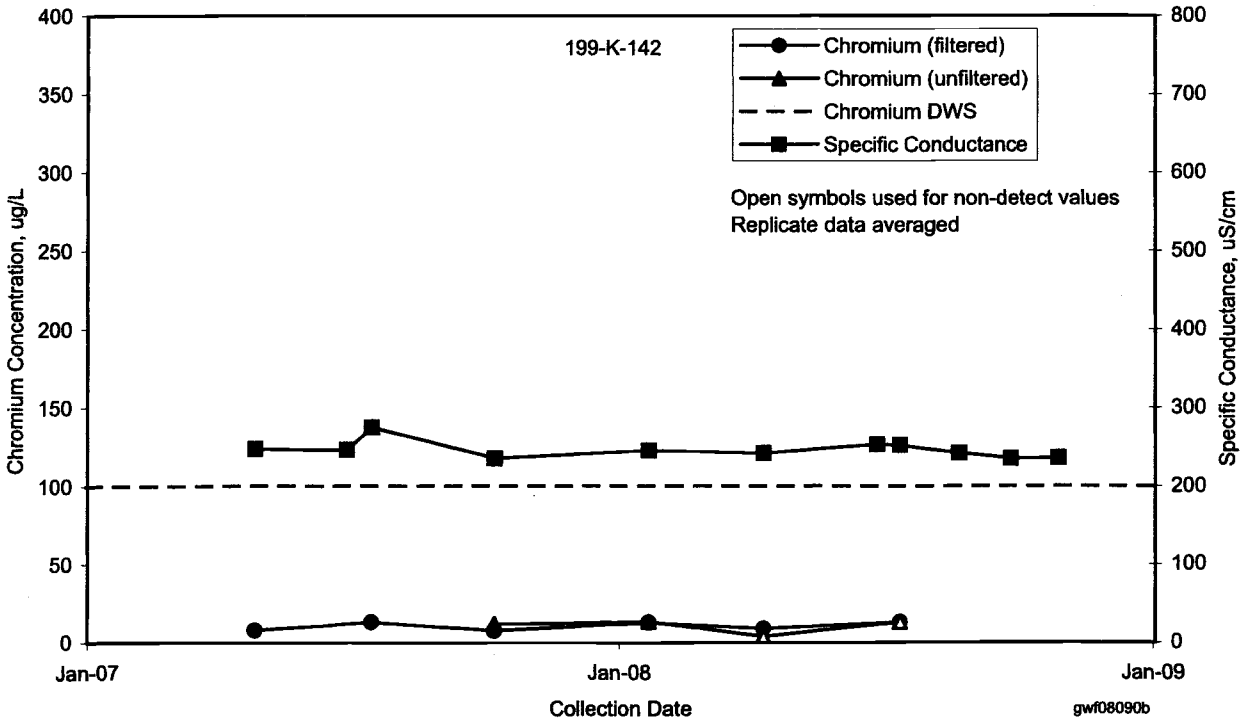


**Figure 2.3-7. Chromium and Specific Conductance Downgradient of the KE Reactor.**




gwf08090

**Figure 2.3-8. Chromium Concentrations in Wells Located at the Southwestern Edge of the 116-K-2 Trench Plume.**

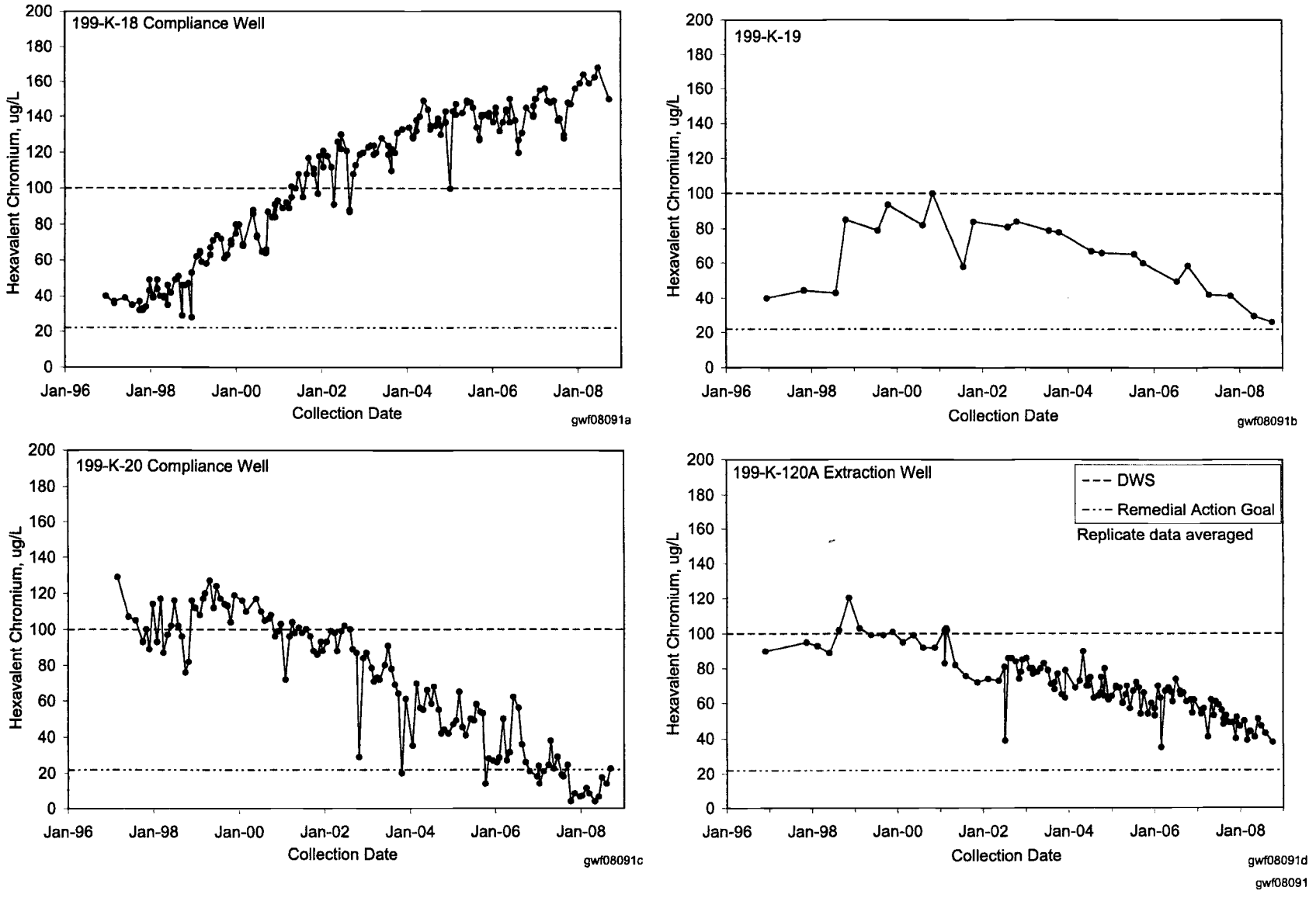


**Figure 2.3-9. Chromium Concentrations in Wells Located in Central Portion of the 116-K-2 Trench Plume.**

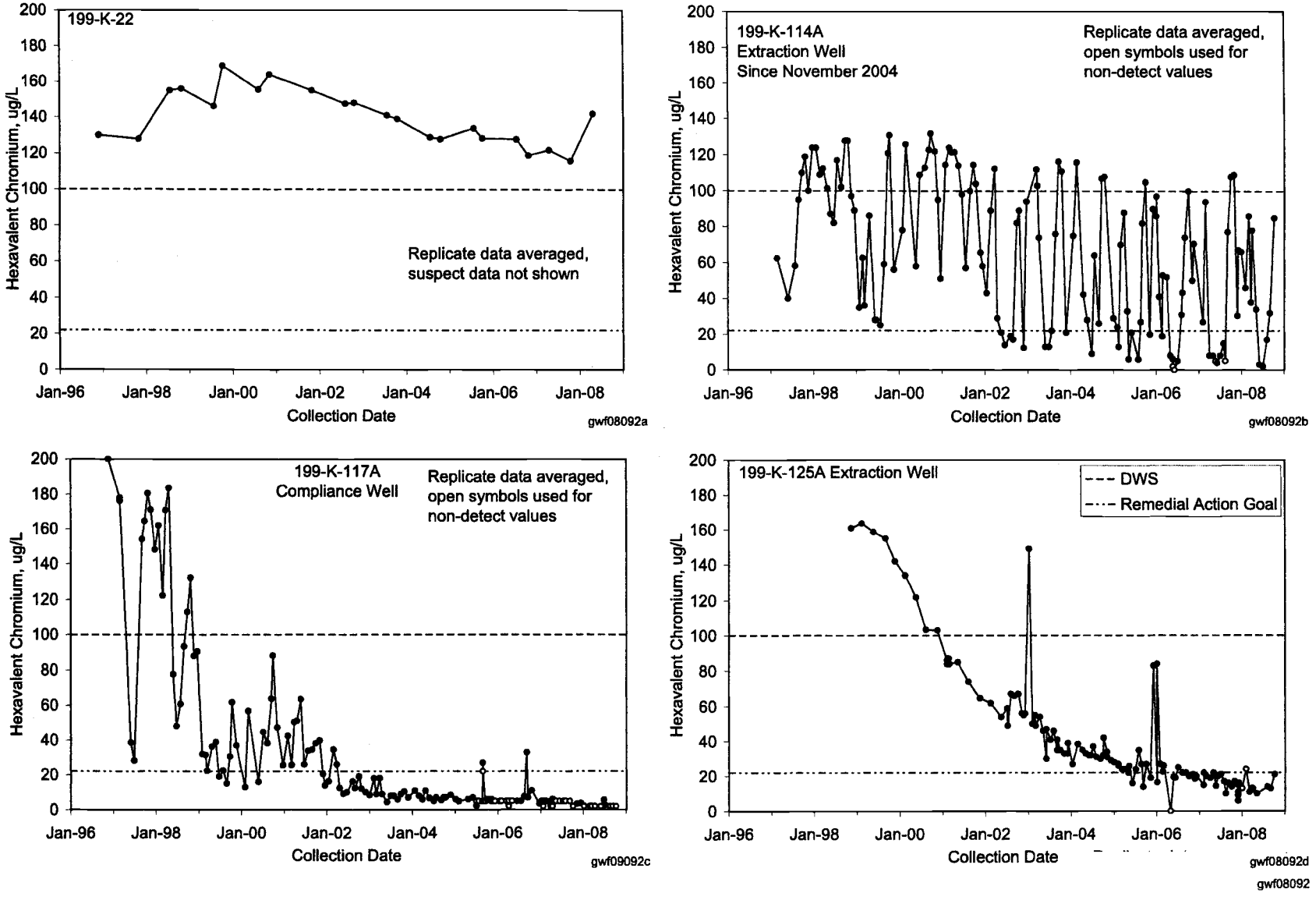


**Figure 2.3-10. Chromium Concentrations in Wells Located at the Northeastern Edge of the 116-K-2 Trench Plume.**

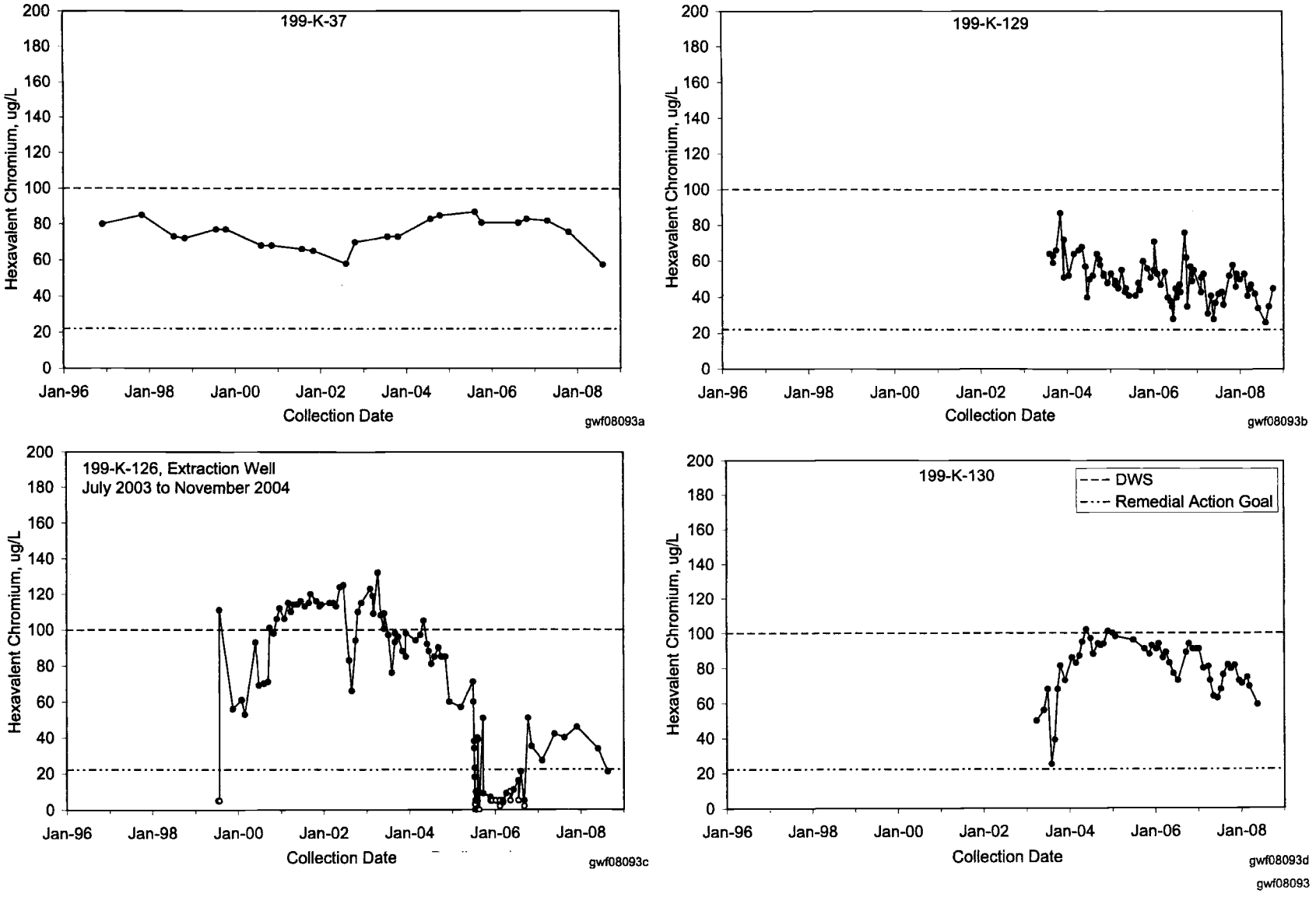


**Figure 2.3-11. Chromium Concentrations in Aquifer Tube 26-D near the Northern Portion of the 116-K-2 Trench Plume.**

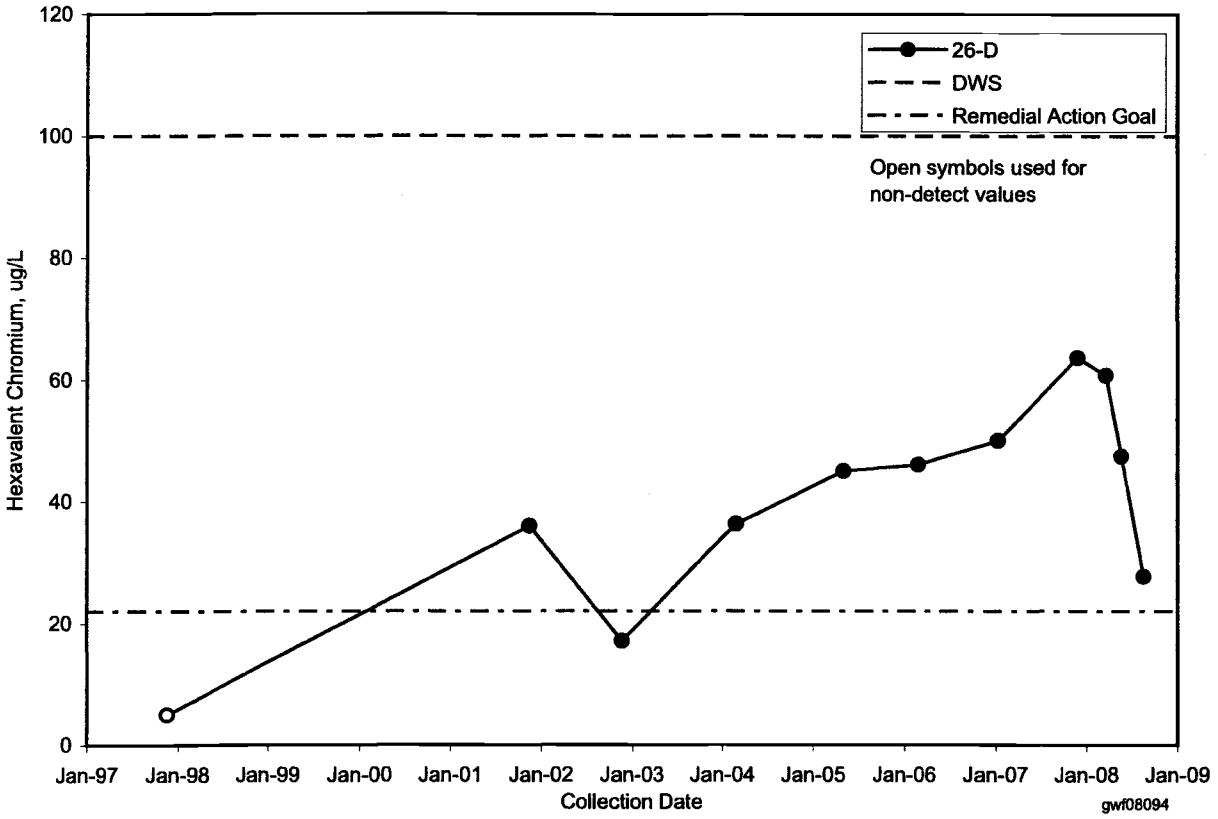


**Figure 2.3-12. Average Tritium Concentrations in the 100-K Area, Upper Part of Unconfined Aquifer.**

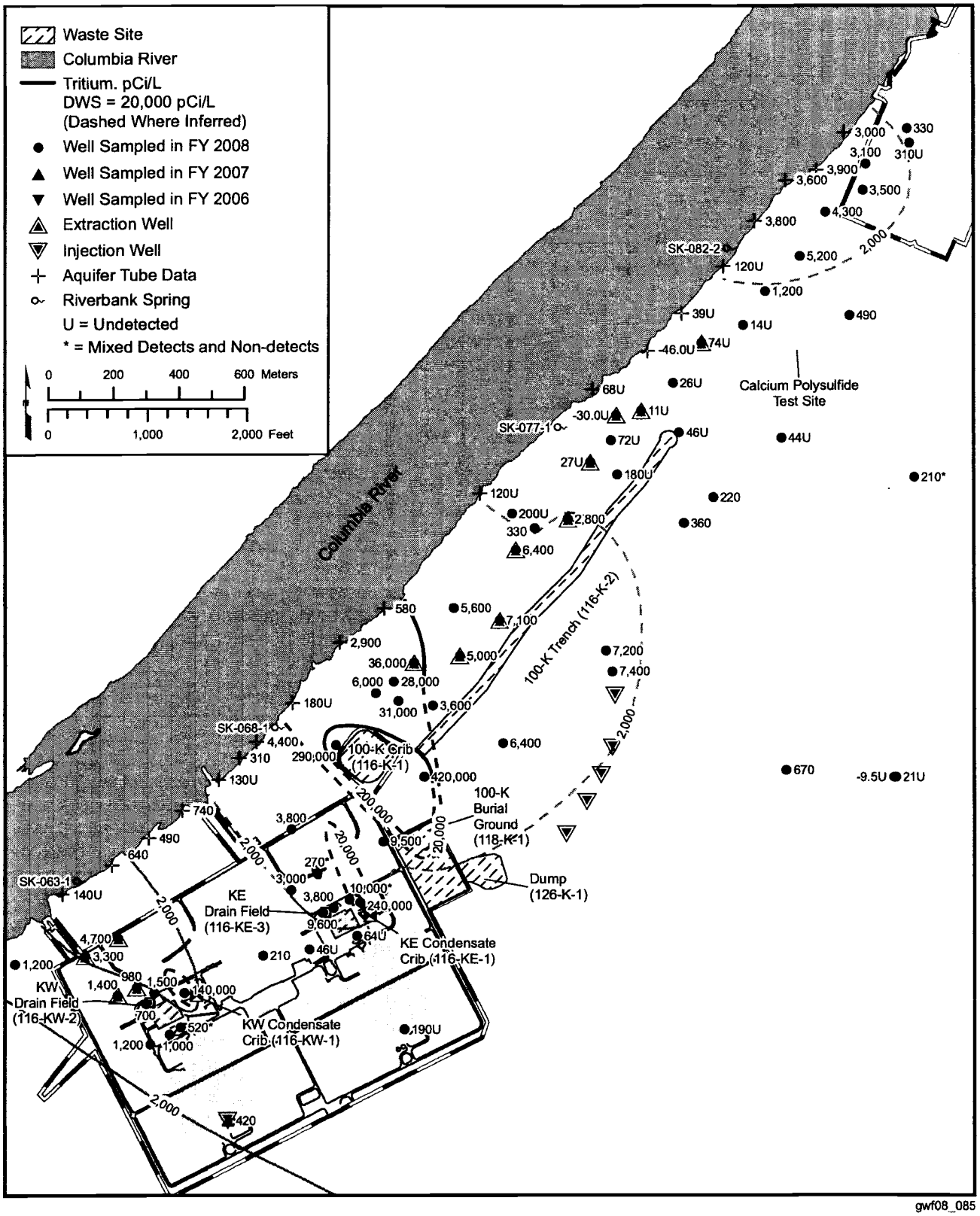


**Figure 2.3-13. Tritium and Carbon-14 Concentrations near the Former 116-KW-1 Condensate Crib.**

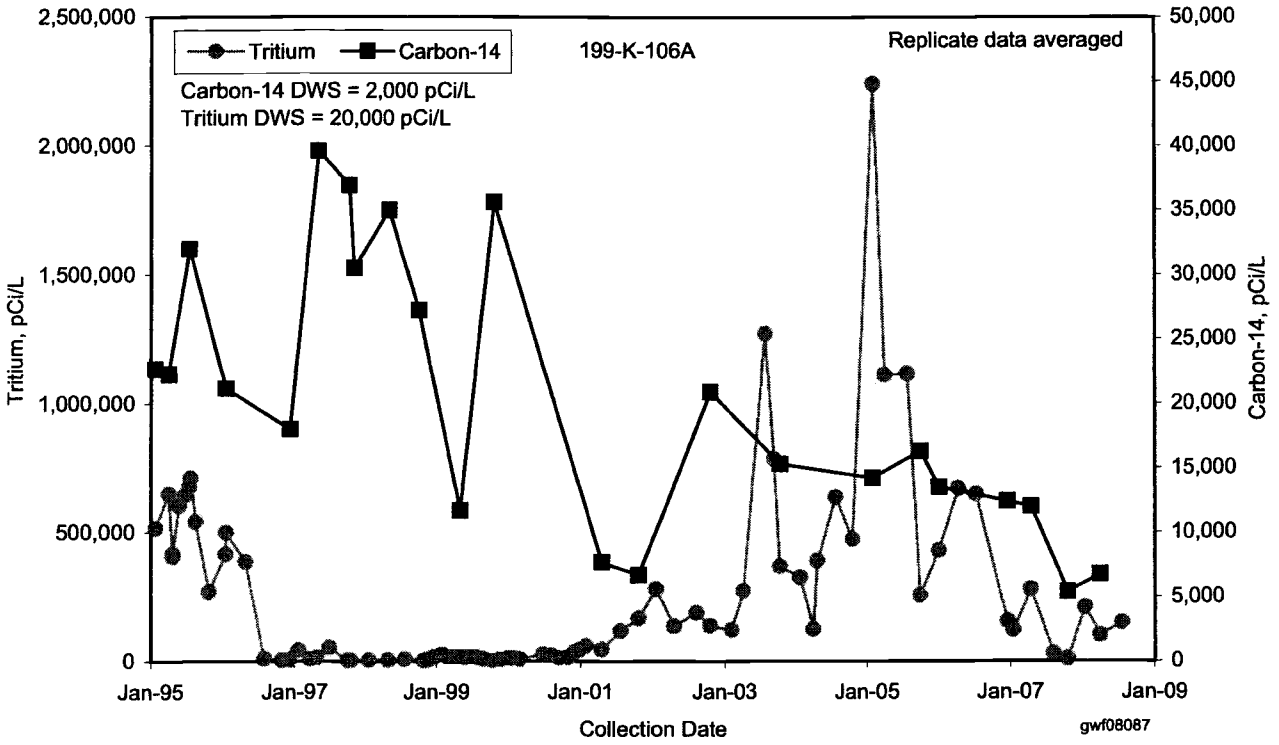



**Figure 2.3-14. Tritium and Carbon-14 Concentrations near the Former 116-KE-1 Condensate Crib.**

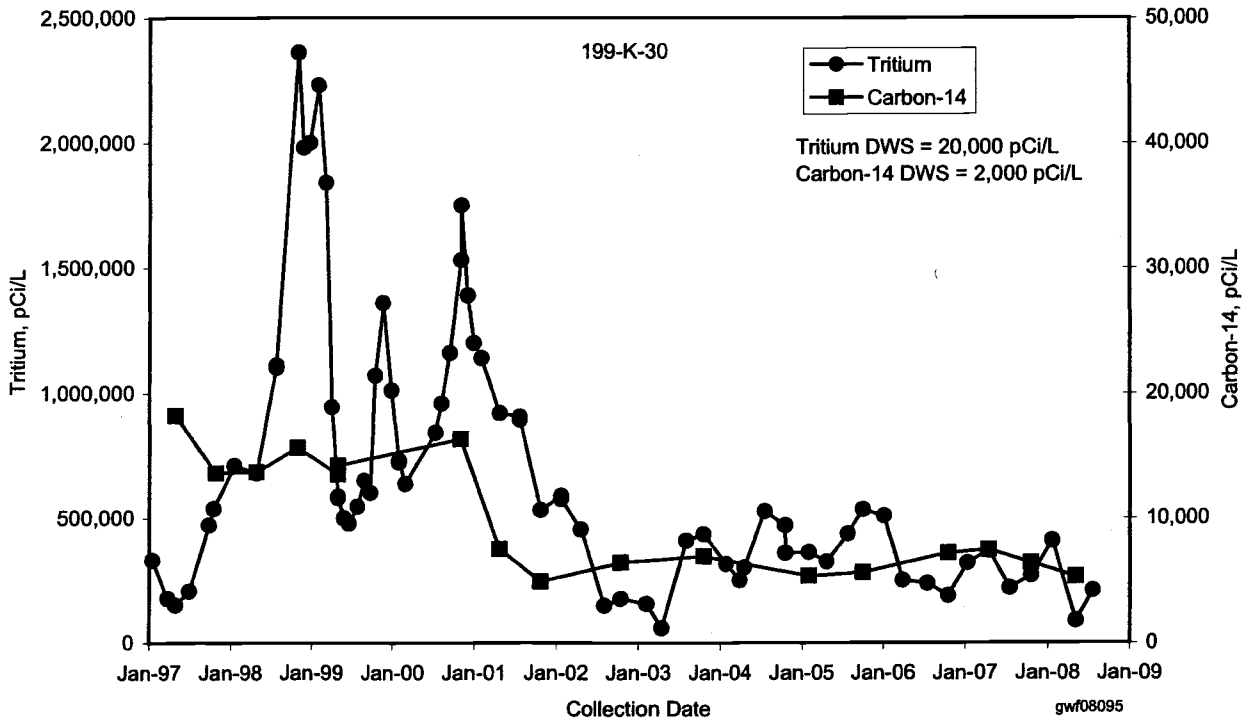


**Figure 2.3-15. Tritium Concentrations Downgradient of the Former KE Basin.**

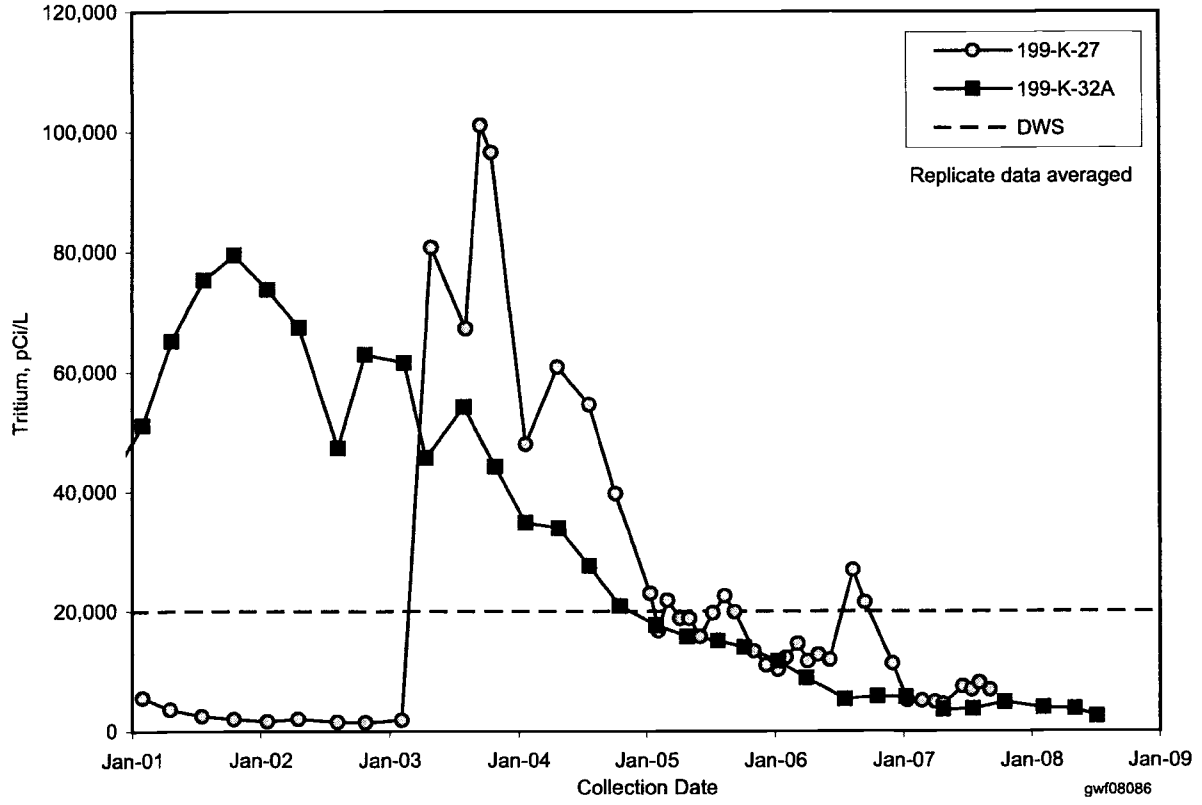



**Figure 2.3-16. Carbon-14 Concentrations in KW Downgradient Wells.**

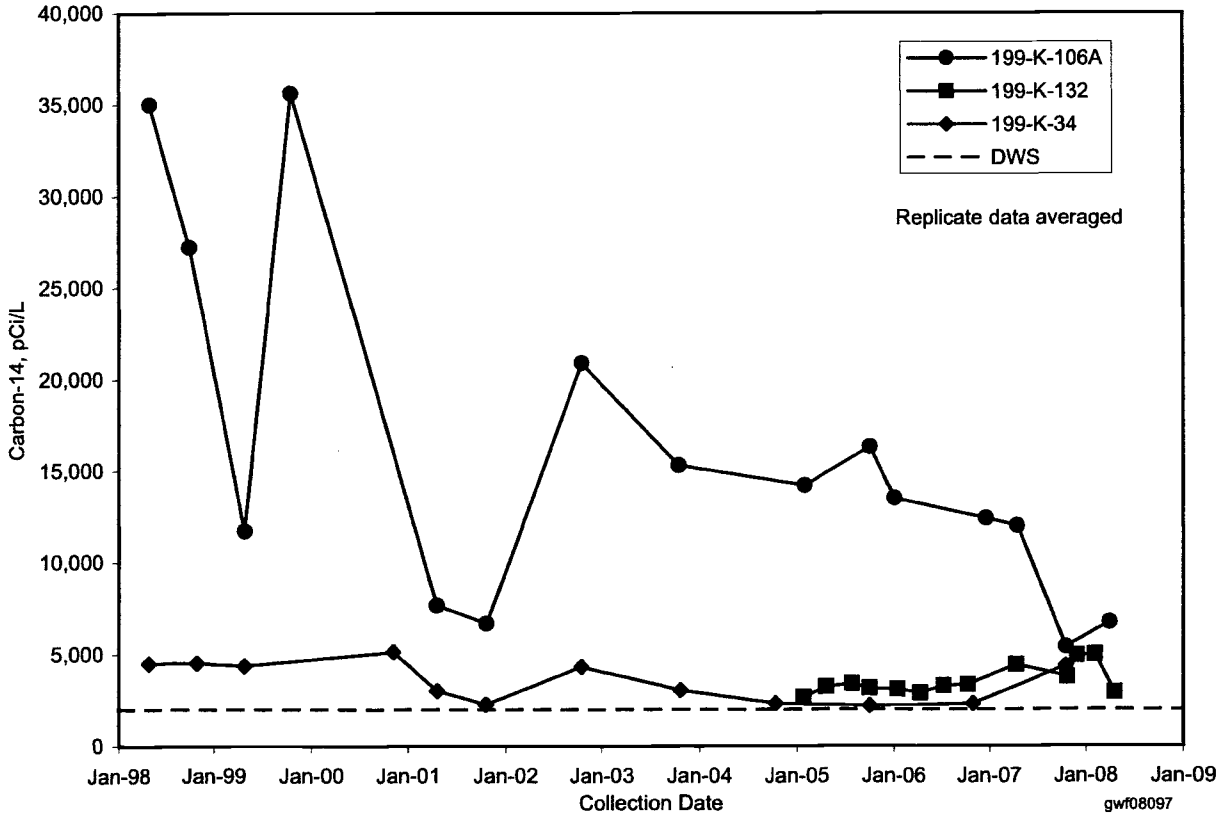


**Figure 2.3-17. Carbon-14 Concentrations in KW Upgradient Wells.**

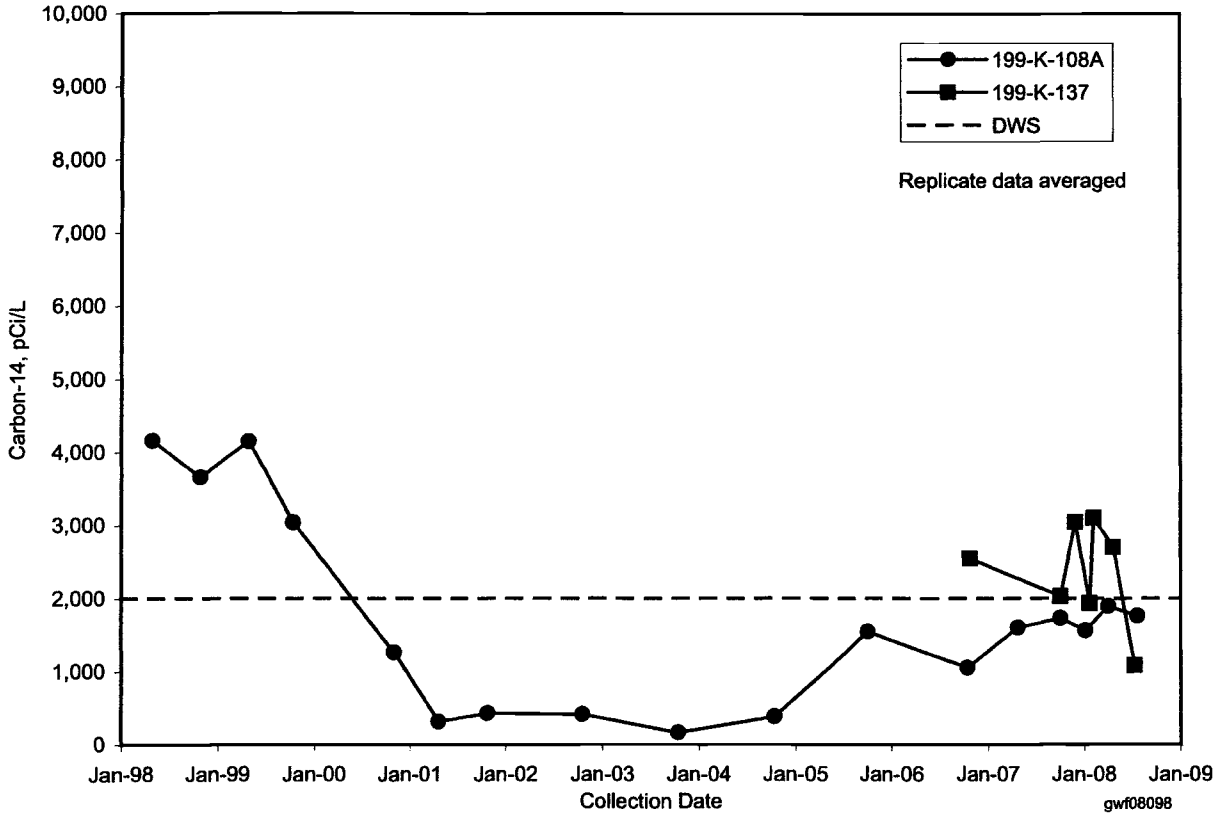
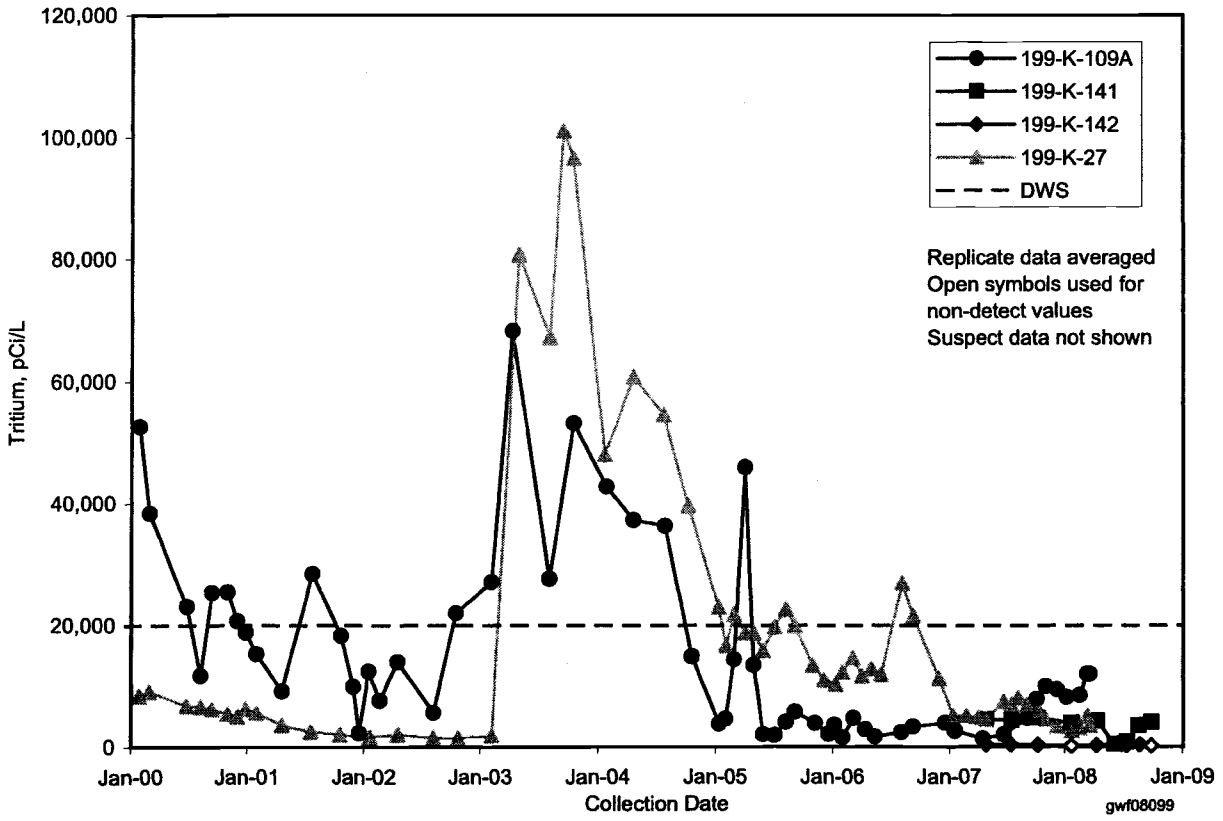



**Figure 2.3-18. Tritium Concentrations near the Former KE Basin.**



# 2.4 100-NR-2 Operable Unit

*M. J. Hartman*

This section describes groundwater flow and chemistry in the 100-NR-2 groundwater interest area, and focuses on the 100-N Area (Figure 1.0-1). The 100-NR-2 Operable Unit includes groundwater affected by contaminant releases from facilities and waste sites within the 100-N Area. Figure 2.4-1 shows facilities and wells in this region and Figure 2.4-2 shows shoreline monitoring sites and wells in an area of particular interest for monitoring.

Groundwater flows primarily to the north and northwest, toward the Columbia River (Figure 2.4-3). Typically, when river stage is high in late spring, the gradient is temporarily reversed and there is a potential for water to flow from the river into the aquifer.

A vertical gradient is not measurable within the unconfined aquifer. The difference in water levels in well pairs (199-N-81 and 199-N-70; 199-N-119 and 199-N-121) was only a few hundredths of a meter in FY 2008, within measurement error. The screen depths differ by ~5 to 6 m.

Some of the main concepts associated with the 100-NR-2 Operable Unit include the following.

- The major liquid waste disposal sites have been excavated and backfilled. Additional contamination remains in the vadose zone.
- Strontium-90 is the principal contaminant of concern in groundwater. The area of the plume has remained stable for many years.
- Strontium-90 tends to stick to sediment grains and is difficult to clean up by traditional methods like pump-and-treat. The U.S. Department of Energy (DOE) is applying an in situ technology, apatite sequestration, to immobilize strontium-90 before it reaches the Columbia River. Apatite-forming chemicals were injected into near-shore wells in 2006, 2007, and 2008. Strontium-90 concentrations initially rose after the injections, but then began to drop as chemical reactions progressed.
- Six new wells were installed to support expansion of the apatite barrier.
- Tritium, nitrate, sulfate, and petroleum hydrocarbons also are present in groundwater.
- Four *Resource Conservation and Recovery Act of 1976* (RCRA) units are located in the 100-N Area. During fiscal year (FY) 2008 the sites remained in detection monitoring programs. One new well was installed and will be monitored beginning in FY 2009.
- Most of the monitoring wells in the 100-N Area monitor the upper part of the unconfined aquifer, which is 10 m thick. Three wells monitor the base of the unconfined aquifer. Another well is screened in a fine-grained unit ~12 m below the water table. The deeper wells are essentially free of strontium-90 contamination. Nitrate concentrations are lower in the deep wells than in the shallow wells. Tritium concentrations are about the same or lower in the deep wells.

The following sections provide details about the operable unit activities. Section 2.4.1 describes contaminant plumes and concentration trends in the vicinity of the 100-N Area. Strontium-90 is the contaminant of concern for a *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) interim action (EPA/541/R-99/112, *Interim Remedial Action Record of Decision for the 100-NR-1 and 100-NR-2 Operable Units, Hanford Site, Benton County, Washington*). Section 2.4.2 provides information on operable unit activities during FY 2008. Section 2.4.3 discusses groundwater monitoring at four facilities monitored under RCRA and the *Atomic Energy Act of 1954* (AEA).

## 2.4.1 Groundwater Contaminants

Wells in the 100-NR-2 Operable Unit are sampled for constituents of concern provided in the interim action record of decision: strontium-90, tritium, nitrate, sulfate, petroleum hydrocarbons, manganese, iron, and chromium.

***Plume areas (square kilometers) in the 100-NR-2 Operable Unit:***

***Nitrate, 45 mg/L — 0.54***
***Strontium-90, 8 pCi/L — 0.58***
***Tritium, 20,000 pCi/L — 0.06***

### 2.4.1.1 Strontium-90

Strontium-90 was present in the liquid effluent discharged to the 116-N-1 Facility (1963 to 1985) and the 116-N-3 Facility (1983 to 1991). Both facilities were excavated to remove highly-contaminated soil, and backfilled with clean soil. The vadose zone and aquifer beneath the facilities remain contaminated with strontium-90, which binds to sediment grains and is moderately mobile in groundwater.

A record of decision stipulates interim remedial action for strontium-90 in the 100-N Area (EPA/541/R-99/112). From 1995 to March 2006, a pump-and-treat system operated between the 116-N-1 Facility and the Columbia River to reduce the amount of contamination entering the river. Because strontium-90 binds to sediment, the pump-and-treat system was not effective in cleaning up the aquifer. The DOE began to implement an in situ remedial action, apatite sequestration, in 2006. Apatite-forming chemicals were injected into the aquifer during the summers of 2006, 2007, and 2008 (Section 2.4.2.3).

***Strontium-90 is the principal groundwater contaminant beneath the 100-NR-2 Operable Unit. The general shape of the plume has not changed in many years.***

The size and shape of the strontium-90 plume changes very little from year to year. The plume extends from beneath the 116-N-1 and 116-N-3 Facilities to the Columbia River at levels above the drinking water standard (8 pCi/L) (Figure 2.4-4). Concentrations exceeding 100 pCi/L are limited to the top ~3 m of the aquifer (PNNL-16346). Concentrations in several wells and aquifer tubes exceeded the derived concentration guide (1,000 pCi/L).

The area where the highest concentrations of strontium-90 reach the Columbia River is of special concern for remediation and monitoring. Figure 2.4-5 shows details of the strontium-90 plume in this region in September 2008. The map shows that strontium-90 concentrations were substantially affected by the recent apatite injections. Strontium-90 concentrations declined in the wells within the barrier and some downgradient wells (199-N-122 and 199-N-147). Concentrations increased in some aquifer tubes. Section 2.4.2.3 explains these changes in more detail.

Strontium-90 trends in monitoring wells near the former 116-N-1 Facility show no obvious, long-term decline in concentrations, but significant variability related to water levels (Figure 2.4-6). When the water table rises beneath the former waste

facilities, strontium-90 from the vadose zone is mobilized and concentrations in groundwater increase. Water levels and strontium-90 concentrations in wells near the 116-N-1 Facility were high in the late 1980s, when liquid effluent was being discharged elsewhere in the 100-N Area, and declined after effluent discharges ceased in 1991. Concentrations rose again in the mid 1990s, which correlated with several years of relatively high river stage. Concentration peaks in each of the past three years were correlated with periods of high water table.

Figure 2.4-7 shows strontium-90 trend in well 199-N-81, near the 116-N-3 Facility. Many of the variations are correlated to water level. However, the concentration increased in September 2008, while the water level dropped.

The strontium-90 contamination is limited to the upper portion of the unconfined aquifer. Wells 199-N-69 and 199-N-70, which are screened at the bottom of the unconfined aquifer, have no detectable strontium-90, while adjacent, shallow wells 199-N-67 and 199-N-81 have high concentrations (Figure 2.4-6 and 2.4-7). Figure 2.4-8 shows the vertical distribution of gross beta[1] in the vertical profile aquifer tubes in June 2007 (high river stage), December 2007, and March 2008 (moderate river stage). The maximum concentrations were measured between 115.7 and 116.3 m elevation in the Ringold Formation, while the deeper tubes had lower concentrations. Concentrations also were much lower in the shallowest aquifer tubes, which monitor the Hanford formation (i.e., top two tubes in NVP1).

### 2.4.1.2 Tritium

The tritium plume has diminished since 1991 when effluent discharge to the 116-N-3 Facility ceased. In FY 2008, only one well had an average concentration exceeding the drinking water standard (20,000 pCi/L). The maximum concentration was 22,000 pCi/L in well 199-N-32, near the 116-N-3 Facility. The concentration in this well dropped below the standard in September 2008 (Figure 2.4-9). Concentrations near the river in well 199-N-14 also dropped below the drinking water standard in FY 2008.

Unlike strontium-90, tritium is present through the entire thickness of the unconfined aquifer. Concentrations in wells 199-N-69 and 199-N-70, completed at the base of the unconfined aquifer, are about the same as in nearby shallow wells. Tritium concentration in well 199-N-80, which monitors a confined aquifer in the Ringold Formation was, 15,000 pCi/L in FY 2008, continuing a declining trend.

### 2.4.1.3 Nitrate

Nitrate concentrations exceed the drinking water standard (45 mg/L) beneath a portion of the 100-N Area (Figure 2.4-10). Although the plume includes wells downgradient of all three of the RCRA units, it also includes upgradient and cross-gradient wells (e.g., 199-N-57 and 199-N-64). Historical nitrate trends in wells near the RCRA units do not indicate that discharges to these units created the nitrate plumes. However, the sources remain unknown.

***Nitrate concentrations continued to exceed the drinking water standard in FY 2008.***

Figure 2.4-11 shows nitrate trend plots for two wells near the 116-N-1 Facility for their entire recorded history. Figure 2.4-12 shows the nitrate trend in a well near the 116-N-3 Facility. At both sites, nitrate concentrations were high in the mid-1980s,

1 Gross beta values are equal to twice the strontium-90 concentration area in the 100-N Area (PNNL-16894).

declined sharply by 1990, and then began to increase again. Levels peaked in FY 2006 and remained high in FY 2008. The reason for the increase is unknown.

Near the 120-N-1 Percolation Pond in south 100-N Area, nitrate concentrations also increased in the 1990s (Figure 2.4-13). During the pond's period of use (1977 to 1990), only low levels of nitrate (~1 mg/L) were detected in effluent to the facility (DOE/RL-96-39, *100-NR-1 Treatment, Storage, and Disposal Units Corrective Measures Study/Closure Plan*, Appendix B). Monitoring began in 1987 and nitrate concentrations in groundwater also were low (1 to 4 mg/L). Nitrate levels have exceeded the drinking water standard in well 199-N-59 since 1998. Nitrate levels have increased in nearby well 199-N-72, and have exceeded the standard since 2005.

Anomalously low nitrate concentrations (undetected) continued to be observed in well 199-N-18. The low concentrations are believed to be caused by chemical reduction of the nitrate caused by biodegradation of hydrocarbons (Section 2.4.1.5). Other chemical constituents and parameters support the interpretation of chemical reduction around well 199-N-18: low dissolved oxygen, low pH, detectable nitrite, and high concentrations of metals (especially manganese and iron). Well 199-N-16 has a variable nitrate trend that also may be related to chemical reduction.

### 2.4.1.4 Sulfate

The former 120-N-1 Percolation Pond introduced sulfate and sodium to 100-N Area groundwater. The highest sulfate concentration in FY 2008 was 251 mg/L in well 199-N-59, adjacent to the 120-N-1 Percolation Pond. This was the only well with a concentration above the 250 mg/L secondary drinking water standard. Sulfate concentrations remain elevated in groundwater north and northwest of the 120-N-1 Percolation Pond. A second area of elevated sulfate concentrations underlies the 116-N-3 Trench. This contamination is residual from previous flow conditions that carried sulfate from the 120-N-1 Percolation Pond inland and then toward the north.

***A thin layer of floating petroleum product continued to be found in one well. Traces of contamination were detected in two aquifer tubes.***

### 2.4.1.5 Petroleum Hydrocarbons

Petroleum hydrocarbons from a 1960s diesel fuel leak (DOE/RL-95-111, *Corrective Measures Study for 100-NR-1 and 100-NR-2 Operable Units*) continued to be detected in 100-N Area groundwater. Of the affected wells, 199-N-18 is closest to the former leak site and had the highest levels of groundwater contamination. In April 2008, this well had 150 mg/L total petroleum hydrocarbons in the diesel range.

The DOE continued a remedial action to remove free product from well 199-N-18 in FY 2008. The passive remediation method employs a polymer that selectively absorbs petroleum products from the surface of the water like a sponge. Two cylinders of this material are lowered into the well, where the material absorbs the contamination. The cylinders are changed every two months when they are saturated with oil.

Evidence of low levels of hydrocarbon contamination has been observed in wells 199-N-3, 199-N-16, 199-N-19, and 199-N-96A in the past (PNNL-14187, *Hanford Site Groundwater Monitoring for Fiscal Year 2002*, Section 2.4), but not in FY 2008. Aquifer tubes 116mArray-0A and C6135 detected low levels of total petroleum hydrocarbons-diesel in FY 2008, up to 0.32 mg/L.

Total organic carbon concentrations were slightly elevated in a few shoreline wells and aquifer tubes near the area of contamination. Concentrations ranged from undetected to 6,060 µg/L in well 199-N-96A during FY 2008.

The DOE recently began work to characterize petroleum contamination in the 100-N Area subsurface (Section 2.4.2.6).

### 2.4.1.6 Manganese and Iron

Manganese concentrations continued to exceed the secondary drinking water standard (50 µg/L) in samples from two wells affected by petroleum contamination: 199-N-16 (371 µg/L filtered; 281 µg/L unfiltered) and 199-N-18 (2,810 µg/L filtered; 7,210 µg/L unfiltered). Iron concentrations also exceeded the secondary drinking water standard (300 µg/L) in well 199-N-18 (16,900 µg/L filtered; 37,000 µg/L unfiltered). Natural biodegradation of the hydrocarbons creates reducing conditions, which increases the solubility of metals, such as manganese and iron, from the well casing or aquifer sediment. The dissolved oxygen content in well 199-N-18 in FY 2008 was 2.4 mg/L, much lower than ambient groundwater (typically ~8 mg/L). Unfiltered samples contained higher levels of metals because the samples from these wells were turbid. During sampling, turbidity ranged from 10 to 56 NTU in well 199-N-16 and from 2.6 to 81 NTU in 199-N-18, which is sampled with a bailer.

***Manganese and iron in 100-N Area groundwater are associated with biodegradation of petroleum hydrocarbons.***

Concentrations of manganese, iron, and other metals increased sharply in shoreline wells and aquifer tubes following injections of apatite-forming chemicals in summer 2008. This effect is described in Section 2.4.3.2.

### 2.4.1.7 Chromium

Only one well in the 100-N Area has dissolved chromium concentrations above the drinking water standard (100 µg/L). Well 199-N-80, which is completed in a thin, confined aquifer in the Ringold Formation, had a chromium concentration in FY 2008 of 172 µg/L in a field-filtered sample, a typical level for this well. Chromium was present in the effluent discharged to the 116-N-1 Facility, but levels in wells monitoring the unconfined aquifer were low while the facility was in use, and remained low through FY 2008. Thus, it is unlikely that the chromium seen in deep well 199-N-80 originated at the 116-N-1 Facility. A down-hole video survey of this well in 2001 observed corrosion of the screen, which could affect chromium levels.

Well 199-N-18 had a high FY 2008 chromium result from an unfiltered sample (493 µg/L). The filtered result was just 13.5 µg/L, indicating the high result was associated with particles and not dissolved chromium (Section 2.4.1.6).

## 2.4.2 Operable Unit Activities

This section summarizes activities related to groundwater in the 100-NR-2 Operable Unit. The principal contaminant of concern is strontium-90. Operable unit activities in FY 2008 included interim action monitoring, and emplacement of a permeable reactive barrier, apatite infiltration tests, phytoremediation studies, and planning for characterization of petroleum hydrocarbon contamination.

### 2.4.2.1 Status of Five-Year Review Action Items

The second CERCLA five-year review was published in November 2006 (DOE/RL-2006-20). The review identified two actions pertaining to the 100-N Area. In FY 2008, the DOE made progress on both actions.

- **Action 6-1.** Implement the treatability test plan for permeable reactive barrier using apatite sequestration (DOE/RL-2005-96, *Strontium-90 Treatability Test Plan for 100-NR-2 Groundwater Operable Unit*) and issue treatability test report (September 1, 2008). This action was completed with the installation of the barrier via low-concentration injections in FY 2007 and high-concentration injections in FY 2008. An interim report was completed in June 2008 (PNNL-17429, *Interim Report: 100-NR-2 Apatite Treatability Test: Low-Concentration Calcium-Citrate-Phosphate Solution Injections for In Situ Strontium-90 Immobilization*) and a final report will be issued in September 2009. Section 2.4.2.3 discusses the apatite barrier.
- **Action 7-1.** Perform additional data collection to support risk assessment, provide previously collected data, and collect additional pore water data from new and existing aquifer tubes. Samplers continued to collect water from aquifer tubes in FY 2008. Section 2.4.1 discusses significant results. Data are included in electronic files accompanying this report. Monitoring will continue in FY 2009 and results will be reported to the Washington State Department of Ecology (Ecology).

### 2.4.2.2 Interim Action Monitoring

A pump-and-treat system operated from 1995 until March 2006 in the 100-N Area as part of a CERCLA interim action (EPA/541/R-99/112). The system removed ~1.8 Ci of strontium-90 from the aquifer. Because strontium-90 binds to sediment grains, the pump-and-treat system was not effective in cleaning the aquifer. One of the requirements of the interim action record of decision was to evaluate technologies to clean up the groundwater. Therefore, Ecology, the U.S. Environmental Protection Agency (EPA), and DOE approved Tri-Party Agreement Change Control Form M-16-06-01 in 2006 requiring the pump-and-treat system be put on cold standby and a permeable reactive barrier be constructed. The interim action record of decision allowed the pump-and-treat system to be shut down with Ecology approval; therefore, no explanation of significant difference to the 1999 interim action record of decision was needed to place the system on cold standby.

***The remedial action objectives in the 100-NR-2 Operable Unit (EPA/541/R-99/112) are as follows.***

- ***Protect the Columbia River from the adverse impact of groundwater contamination by limiting exposure pathways, reducing or removing sources, controlling groundwater movement, or reducing the concentration of contaminants.***
- ***Protect the unconfined aquifer by implementing remedial actions that reduce the concentration of contaminants.***
- ***Obtain information to evaluate technologies to remove strontium-90 and evaluate the impact to ecological receptors.***
- ***Prevent destruction of sensitive wildlife habitat and minimize the disruption of cultural resources.***

***In 2006, Ecology added a requirement for the pump-and-treat system to be put on standby, and an alternative, in situ treatment technology to be tested.***

The groundwater monitoring requirements for the 100-NR-2 Operable Unit interim action are specified by Tri-Party Agreement Change Control Form M-15-96-08. These requirements remain in effect even though the pump-and-treat system is on standby, because the change control form has not been superseded. This monitoring also supports requirements of the AEA for site-wide groundwater monitoring. Wells,

constituents, and sampling frequencies for interim action monitoring are shown in Appendix A. During FY 2008, three wells were not sampled as scheduled. Well 199-N-21 was not sampled, pending repair of the pump. Well 199-N-26 is located in a dig site and samplers could not access the well. The planned September sampling of well 199-N-18 was delayed until early FY 2009. Additional details on interim action monitoring for calendar year 2007 are available in DOE/RL-2008-05. Results for calendar year 2008 will be published in an upcoming report.

The DOE continued to perform supplemental monitoring of the shoreline area (PNNL-15798, *100-N Shoreline Groundwater Monitoring Plan*). For two years after the pump-and-treat system went on standby, this included rebound monitoring of former extraction wells and nearby monitoring wells. That period concluded in March 2008 and sampling frequency of some wells decreased (Appendix A). The shoreline plan also includes monitoring of aquifer tubes and shoreline wells, which continued in FY 2008 and was coordinated with monitoring for the apatite barrier.

### 2.4.2.3 Permeable Reactive Barrier

***D. J. Alexander***

The DOE has agreed to construct and evaluate the effectiveness of a permeable reactive barrier, using apatite sequestration technology, as part of the CERCLA remedial investigation/feasibility study process and consistent with the interim remedial action record of decision for the 100-NR-1 and 100-NR-2 Operable Units (EPA/541/R-99/112; Tri-Party Agreement Change Control Form M-16-06-01). Strontium-90 sequestration by this technology occurs through the injection of a calcium citrate phosphate solution. Once injected, biodegradation of the citrate results in apatite precipitation and strontium-90 substitutes for calcium in the mineral matrix when apatite crystallization occurs.

The apatite treatability test site extends ~90 m along the 100-N Area shoreline (Figure 2.4-2). Forty-five monitoring points are associated with this site, including injection/barrier wells, monitoring wells, and aquifer tubes (Appendix A). Sixteen wells comprise the permeable reactive barrier. Six new apatite injection wells (199-N-159, 199-N-160, 199-N-161, 199-N-162, 199-N-163, and 199-N-164) were installed in FY 2008. Four monitoring wells are located between the river and the barrier. The injection/barrier wells at each end of the barrier (wells 199-N-137 and 199-N-138) were used for pilot tests during FY 2006 and FY 2007. The pilot test sites include additional, smaller-diameter monitoring wells surrounding the injection/barrier wells. Results of low-concentration injections conducted in FY 2006 and 2007 were published in PNNL-17429, *Interim Report: 100-NR-2 Apatite Treatability Test: Low-Concentration Calcium-Citrate-Phosphate Solution Injections for In Situ Strontium-90 Immobilization*. Final results, including the high-concentration injections of FY 2008, will be published in September 2009.

***Groundwater project staff injected apatite-forming chemicals into the aquifer to reduce movement of strontium-90 into the Columbia River.***

Strontium-90 contamination in the 100-N Area is primarily absorbed to sediment grains by ion exchange in the upper portion of the unconfined aquifer and lower vadose zone. Scientists estimate that 99% of the contamination is absorbed and only 1% is in solution in the groundwater. Although primarily absorbed, strontium-90 is mobilized by seasonal river stage increases and by plumes of higher ionic strength water (PNNL-16891, *Hanford 100-N Area Apatite Emplacement: Laboratory Results of Ca-Citrate-PO4 Solution Injection and Sr-90 Immobilization in 100-N Sediments*).

Field testing during FY 2007 showed that the test site can be categorized by two general hydrologic conceptual models based on the specific capacity[2] and the contrast between the hydraulic conductivities of the Hanford and Ringold Formations. The southwestern portion of the barrier, between injection wells 199-N-138 and 199-N-141, has relatively low specific capacity and a lower contrast in hydraulic conductivity. The northeastern portion of the barrier, between injection wells 199-N-142 and 199-N-137, has generally higher specific capacity and a larger contrast in hydraulic conductivity. The Hanford formation has higher hydraulic conductivity in the northeastern portion than in the southwestern portion of the barrier. The injections conducted in FY 2008 were modified to account for these differences in hydraulic properties. The southwestern portion achieved adequate treatment by injecting wells screened across both formations. Northeastern wells had to be injected in two phases, one to treat the Ringold Formation and one to treat the Hanford formation.

Staff conducted five injection phases in FY 2008: the first at wells 199-N-137 and 199-N-138 in June, and four more along the length of the barrier from late June until late July. Injections were timed to correspond with high flow periods of the Columbia River, which enabled a better injection of the Hanford formation.

Information provided in 0078408, "100/300 Area Unit Managers Meeting Minutes," Attachment 2, describes monitoring requirements for the treatability test. Post-injections samples were collected starting the day the injection ceased. Specific monitoring points for each injection were sampled daily the first week, every other day the second week, and weekly for four more weeks. Samples were analyzed for gross beta (for strontium-90 determinations), metals, and anions (Appendix A). Citrate samples were collected for the first two weeks following an injection to track biodegradation of the citrate due to interaction with in-situ soil microbes.

Most of the wells and aquifer tubes showed a significant increase in cations and anions in solution following an injection, because of the higher ionic strength solution that was injected. Cation and anion concentrations generally decreased over time following an injection. There was some variability on how the different monitoring points reacted over the length of the barrier based on hydrologic conditions discussed above.

***Gross beta concentrations temporarily increased in response to injections to the apatite barrier. Levels subsequently dropped, and are expected to continue to decline as the remediation takes effect.***

High levels of total dissolved solids in injected solutions temporarily mobilized strontium-90 by ion exchange. The highest concentration of gross beta was seen in aquifer tube NVP2-116.0 (Figure 2.4-14). The maximum gross beta concentration was 150,000 pCi/L on July 24, equating to 75,000 pCi/L strontium-90. Gross-beta concentrations dropped from their peak by early September (5,100 pCi/L) but remained higher than levels before injections. The spikes in gross-beta concentration were a result of injections in nearby wells.

The highest gross beta level in a well was 51,000 pCi/L in well 199-N-162 on July 15 (Figure 2.4-15). The concentration had declined to 86 pCi/L by early September.

Figure 2.4-16 shows trends of gross beta for two pairs of injection/barrier wells and the nearest downgradient monitoring well for each pair. Concentrations initially increased in all the wells because of the high ionic strength injections. All wells showed a general decrease in gross beta concentrations following the injection, except well 199-N-159. Many factors affect the chemistry of the soil and water interaction,

2 Specific capacity is a measure of pumping rate per unit drawdown and relates to hydraulic conductivity of the aquifer.

including changes in river level and differences in hydraulic conductivity and soil matrix.

Barrier injections completed prior to spring 2008 used lower concentrations of the calcium-citrate-phosphate solution. To determine if apatite was forming in the soil matrix from the 2007 injections, tests were conducted on sediment collected when six additional injection/barrier wells were installed in spring 2008. Samples were taken at 0.3 m intervals from 2.1 to 7.6 m below ground surface in each well, for a total of 120 samples. Phosphate profiles with depth in all six wells clearly showed much more apatite in the Hanford formation than the Ringold Formation. This was likely because of the larger volume of solution that permeated this formation during injections in the fully screened wells. Phosphate extraction data from these tests indicated that at a radial distance of ~4.6 m from the adjacent injection wells, the Hanford formation received an average treatment of 110% and the Ringold Formation an average treatment of 30% of the targeted apatite content (PNNL-17429). Further study is ongoing to determine the progress and mechanisms of strontium-90 attenuation.

Monitoring at the apatite barrier will be performed bimonthly through the fall, winter, and early spring of 2008 and 2009. All forty-five monitoring points listed in Appendix A will be sampled, weather and river level permitting. The wells completed only in the Hanford formation are dry at low river stages. Aquifer tubes may not produce water during the winter because of freezing conditions. Sampling will be scheduled during periods of warmer weather whenever possible to ensure the best sample set is collected.

### 2.4.2.4 Apatite Infiltration Tests

Apatite injections treat the strontium-90 contamination in the aquifer, but much of the contamination is in the vadose zone. Pacific Northwest National Laboratory is conducting a study of apatite infiltration to treat vadose zone contamination under an Environmental Management Technology (EM-22) program. The study will investigate whether it is viable to emplace apatite precipitate in the lower half of the vadose zone with surface infiltration of a calcium-citrate-phosphate solution. Results of the study will be used to design an efficient and effective infiltration strategy that will be tested at a field scale.

***Researchers are testing surface infiltration to emplace apatite in the lower vadose zone and immobilize strontium-90 above the water table.***

In FY 2008, researchers built a large, two-dimensional apparatus for simulating infiltration in the laboratory. The apparatus is 2.4 m high, 1.2 m wide, and 1.1 cm thick. This apparatus was packed with Hanford formation material with a matrix of less than 4 mm sediment interspersed with five layers of finer and coarser grained sediment. Testing results from the large two-dimensional system will be used to evaluate and modify an infiltration strategy developed in earlier, smaller scale experiments.

A series of five two-dimensional infiltration experiments were conducted in FY 2008 to test whether sequential infiltration events (with a week reaction time before the subsequent event) will efficiently increase the mass of apatite precipitate. Preliminary analysis showed that the apatite mass increased with each subsequent infiltration event. However, while the apatite mass increased at all depths, the zone of greatest increase was nearest the water table. The researchers are constructing two-dimensional maps of the apatite distribution, which will be used to determine the efficiency of subsequent injections. Results will be reported during FY 2009.

Field testing is planned for FY 2009. An infiltration gallery of shallow piezometers will be installed ~3 m northeast of well 199-N-153 to facilitate infiltration testing. Initial tests will be conducted with plain water.

### 2.4.2.5 Phytoremediation

Phytoremediation has been identified as a potential technology for the removal of strontium-90 from the soil as a filter for groundwater along the Columbia River at the 100-N Area. Phytoremediation is a remediation technology in which plants are used to extract or sequester contaminants. Greenhouse studies have demonstrated the viability of phytoremediation to remove strontium-90 from soil and water in the 100-N Area. The technology would be used in conjunction with the apatite barrier.

Pacific Northwest National Laboratory is conducting a study of phytoremediation, under the EM-22 program. A demonstration plot of coyote willow plants was established in March 2007 along the banks of the Columbia River at the 100-K Area. The area chosen for the test was not contaminated by strontium-90 or any other radionuclide. Objectives of the initial testing phase include determining how much biomass is produced, how strontium and calcium are partitioned in the plant, and the extent of leaf litter. The test plot was maintained in FY 2008 and the leaf-bearing branches were harvested. Researchers will conduct tests on the harvested vegetation and evaluate results in FY 2009.

### 2.4.2.6 Characterization of Petroleum Contamination

### D. J. Alexander

The continuing presence of petroleum hydrocarbons in 100-N Area groundwater indicates that contamination from old diesel leaks remains in the vadose zone. The potential behavior of this contamination in response to river/groundwater dynamics is an important aspect of the conceptual model of the 100-NR-2 Operable Unit. This type of floating source will tend to be retained in the top of the aquifer and the capillary fringe above the water table. The hydrocarbons are relatively insoluble in water and are unlikely to be found in biota; however, they may accumulate in sediment and soil.

The DOE has begun work to characterize the subsurface petroleum contamination in the 100-N Area. The results will support ecological risk assessments and relate to an item in the interim action record of decision, which states, "remove petroleum hydrocarbons from any monitoring well."

*The DOE has begun work to characterize the subsurface petroleum contamination in the 100-N Area.*

As discussed in Section 2.4.1.5, hydrocarbon contamination is still seen in monitoring wells, and traces are detected at the shoreline in aquifer tubes. Other evidence of contamination includes observations of rust-like deposits (i.e., iron oxide) along the shoreline that indicated potential anoxic conditions, and observations of a dark soil layer that smelled of diesel in shallow shoreline excavations. Diesel product also was recovered during drilling of wells 199-N-122 and 199-N-123, and examination of borehole material revealed accumulation of iron oxide, again indicative of anoxic conditions.

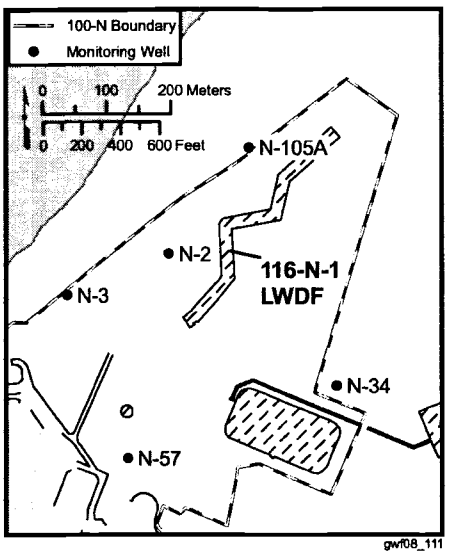
Characterization work planned for FY 2009 includes installation of a well located ~120 m southwest (upriver) of the apatite barrier. The well will be located between the known diesel spill area (located near monitoring well 199-N-18) and the aquifer tubes where low levels of total petroleum hydrocarbons, dissolved iron and manganese have been detected. Samples will be collected to determine levels of contamination and to evaluate existing cleanup technologies, create a treatability test plan, and deploy the selected technology.

## 2.4.3 Facility Monitoring

This section describes results of monitoring individual facilities: the 116-N-1 and 116-N-3 Facilities, 120-N-1 Percolation Pond, and 120-N-2 Surface Impoundment. Groundwater is monitored at these facilities to meet the requirements of RCRA for hazardous waste constituents and AEA for source, special nuclear, and by-product materials. Data from facility-specific monitoring also are integrated into the CERCLA groundwater investigations. Hazardous constituents and radionuclides are discussed jointly in this section to provide comprehensive interpretations for each facility. Groundwater data for these facilities are available in the Hanford Environmental Information System database and in the data files accompanying this report. Appendix B includes well and constituent lists, maps, flow rates, and statistical tables for the 100-N RCRA units.

### 2.4.3.1 116-N-1 (1301-N) Liquid Waste Disposal Facility

This facility contaminated groundwater with radionuclides during its period of use in the 1960s through 1985. Strontium-90 and nitrate concentrations in groundwater exceed drinking water standards. Results of monitoring were discussed in Section 2.4.1. The facility has been excavated to remove shallow vadose zone sediment, where most of the radionuclide contamination resided, and was backfilled. Wells downgradient of the 116-N-1 Facility are sampled quarterly to annually for strontium-90 and gamma activity. No gamma-emitters were detected in FY 2008.




This facility is included in the Hanford Facility RCRA Permit (WA7890008967). The Permit states that RCRA monitoring during closure activities will follow the requirements of BHI-00725, *100-N Pilot Project: Proposed Consolidated Groundwater Monitoring Program*. That plan and a supplemental plan (PNNL-13914, *Groundwater Monitoring Plan for the 1301-N, 1324-N/NA, and 1325-N RCRA Facilities*) are similar to an interim status indicator evaluation program (40 CFR 265.93(b), as referenced by WAC 173-303-400).

Groundwater flows to the northwest beneath the 116-N-1 Facility, discharging to the Columbia River. The hydraulic gradient in March 2008 was 0.0014, and flow rate was estimated to be between 0.03 to 0.53 m/day (Appendix B).

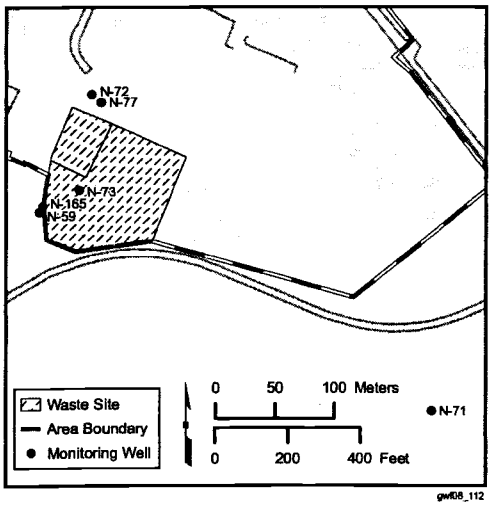
Upgradient and downgradient wells are scheduled for sampling twice each year for RCRA contamination indicator parameters (pH, specific conductance, total organic carbon, and total organic halides) and once for groundwater quality and site-specific parameters. The wells were sampled as scheduled in FY 2008.

Average specific conductance in downgradient well 199-N-3 continued to exceed the critical mean value (1,333 µS/cm) in March 2008. This was a continuation of previous exceedances, and prior assessment results (WHC-SD-EN-EV-003, *Results of Groundwater Quality Assessment Monitoring at the 1301-N and 1324-N/NA Facilities*) indicated the elevated specific conductance is related to constituents from the 120-N-1 Percolation Pond. Recent data indicate this conclusion remains valid (DOE/RL-2008-01, Appendix B). The average specific conductance dropped below the critical mean value in September 2008.

In March 2008, well 199-N-3 exceeded the critical mean value for total organic carbon (1,816 µg/L). The well was resampled in July 2008, and split sample sets were sent to two laboratories. The average result was below the critical mean value.

Upgradient/downgradient comparison values for indicator parameters have been revised based on recent data for use in FY 2009 comparisons (Appendix B).

### 2.4.3.2 120-N-1 (1324-NA) Percolation Pond and 120-N-2 (1324-N) Surface Impoundment




These facilities were used to treat and dispose of corrosive, nonradioactive waste from 1977 to 1990. They have been remediated and backfilled.

These facilities are included in the Hanford Facility RCRA Permit. The Permit states that RCRA monitoring during closure activities will follow the requirements of BHI-00725. That plan, and a supplemental plan (PNNL-13914), are similar to an interim status indicator evaluation program (40 CFR 265.93(b), as referenced by WAC-173-303-400). The two units are monitored as a single site (waste management area) because of their proximity and similar waste type.

Groundwater flows to the northwest beneath the 120-N-1 and 120-N-2 Facilities, discharging to the Columbia River. The hydraulic gradient in March 2008 was 0.0022, and flow rate was estimated to be between 0.05 to 0.82 m/day (Appendix B).

During FY 2008, four of the five monitoring wells for this site were sampled twice for RCRA contamination indicator parameters and groundwater quality and once for site-specific parameters, as planned (Appendix B). Downgradient well 199-N-59 contained too little water to sample in December 2007, but was successfully sampled in June 2008. A replacement well, 199-N-165, was installed in FY 2008, and will be sampled in FY 2009.

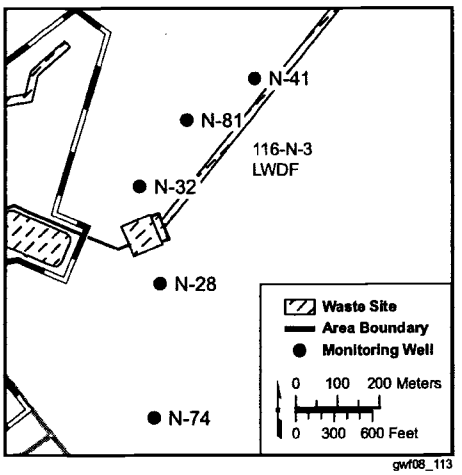
Average specific conductance values in wells downgradient of the facilities continued to exceed the critical mean value in FY 2008. A previous groundwater quality assessment indicated that the high specific conductance is caused by sulfate and sodium (WHC-SD-EN-EV-003), which are not listed hazardous waste constituents. Recent data indicate this conclusion remains valid (DOE/RL-2008-01, Appendix B).

The average of total organic halides results from upgradient well 199-N-71 and downgradient well 199-N-72 exceeded the critical mean value of 26.3 µg/L in December 2007. The data had poor precision. The wells were resampled and results indicated the initial results were erroneous.

Total organic carbon data from downgradient well 199-N-72 were anomalous in June 2008. Quadruplicates from one laboratory ranged from 2,200 to 23,000 µg/L, while split results from another laboratory were in the hundreds of micrograms per liter. The anomalous samples were reanalyzed and results came back much lower (less than 400 to 480 µg/L). Staff are continuing to investigate what caused the recent anomalies.

Upgradient/downgradient comparison values for indicator parameters were revised based on recent data for use in FY 2009 comparisons (Appendix B). Wells in this RCRA network have been sampled in December and June for the past several years. The schedule was chosen because it increased the chance of sampling nearly-dry well 199-N-59 during high water-table conditions (June). A replacement well (199-N-165) was installed in early FY 2009. Well 199-N-165 is deeper, so beginning in FY 2009 the network will be sampled in March and September like the other 100-N Area wells.

### 2.4.3.3 116-N-3 (1325-N) Liquid Waste Disposal Facility




This facility contaminated groundwater with radionuclides during its period of use from 1983 to 1991. Nitrate, strontium-90, and tritium concentrations in groundwater downgradient of the facility exceed drinking water standards. Section 2.4.1 discusses monitoring results. The facility was excavated to remove the shallow vadose zone material, which contained the highest concentrations of radionuclides, and backfilled.

This facility is included in the Hanford Facility RCRA Permit. The Permit states that RCRA monitoring during closure activities will follow the requirements of BHI-00725. That plan, and a supplemental plan (PNNL-13914), are similar to an interim status indicator evaluation program (40 CFR 265.93(b), as referenced by WAC 173-303-400).

Groundwater flows to the north beneath the 116-N-3 Facility, then turns to the northwest and discharges to the Columbia River. The hydraulic gradient in March 2008 was 0.0010, and the groundwater flow rate was estimated to be between 0.02 to 0.38 m/day (Appendix B).

All five wells were sampled twice for RCRA contamination indicator parameters (pH, specific conductance, total organic carbon, and total organic halides) and once for groundwater quality and site-specific parameters, as planned. However, samplers neglected to take quadruplicate field readings in one well in March (Appendix B).

Average specific conductance values in downgradient wells 199-N-32 and 199-N-41 continued to exceed the critical mean value at least once in FY 2008. These were continuations of previous exceedances noted in 1999 through 2007. The DOE notified Ecology of the original exceedance and submitted an assessment report (00-GWVZ-054, "Results of Assessment at the 1325-N Facility") that concluded the exceedance was caused by past discharges to the 120-N-1 Percolation Pond. Recent data indicate this conclusion remains valid (DOE/RL-2008-01, Appendix B).

Detection monitoring will continue in FY 2009. Upgradient/downgradient comparison values for indicator parameters were revised based on recent data for use in FY 2009 (Appendix B).

***Groundwater monitoring in the 100-NR-2 groundwater interest area includes the following monitoring activities.***

***CERCLA and AEA Monitoring (Appendix A)***

- ***Twenty-nine wells are scheduled for monthly to annual sampling for purposes of the original interim action. Three wells were not sampled as planned.***
- ***Thirty-seven wells and eight aquifer tubes were sampled daily following the injection of apatite-forming chemicals, and at lower frequencies thereafter.***
- ***The DOE installed six new wells to support expansion of the apatite barrier and 19 new aquifer tubes to help define plumes.***
- ***Twenty wells and twenty-eight aquifer tubes are scheduled for monthly to annual sampling under a shoreline groundwater-monitoring plan, coordinated with apatite barrier monitoring.***

***Facility Monitoring (Appendix B)***

- ***Five wells are scheduled for semiannual sampling for the 116-N-1 Liquid Waste Disposal Facility for requirements of RCRA and AEA. The wells were sampled as planned.***
- ***Five wells are scheduled for semiannual sampling for the 120-N-1 Percolation Pond and 120-N-2 Surface Impoundment for requirements of RCRA and AEA. One well was sampled only once because of low water levels. A replacement well was installed and will be sampled beginning in FY 2009.***
- ***Five wells are scheduled for semiannual sampling for the 116-N-3 Liquid Waste Disposal Facility for requirements of RCRA. The wells were sampled as planned.***

**Figure 2.4-1. Facilities and Groundwater Monitoring Wells in 100-N Area.**

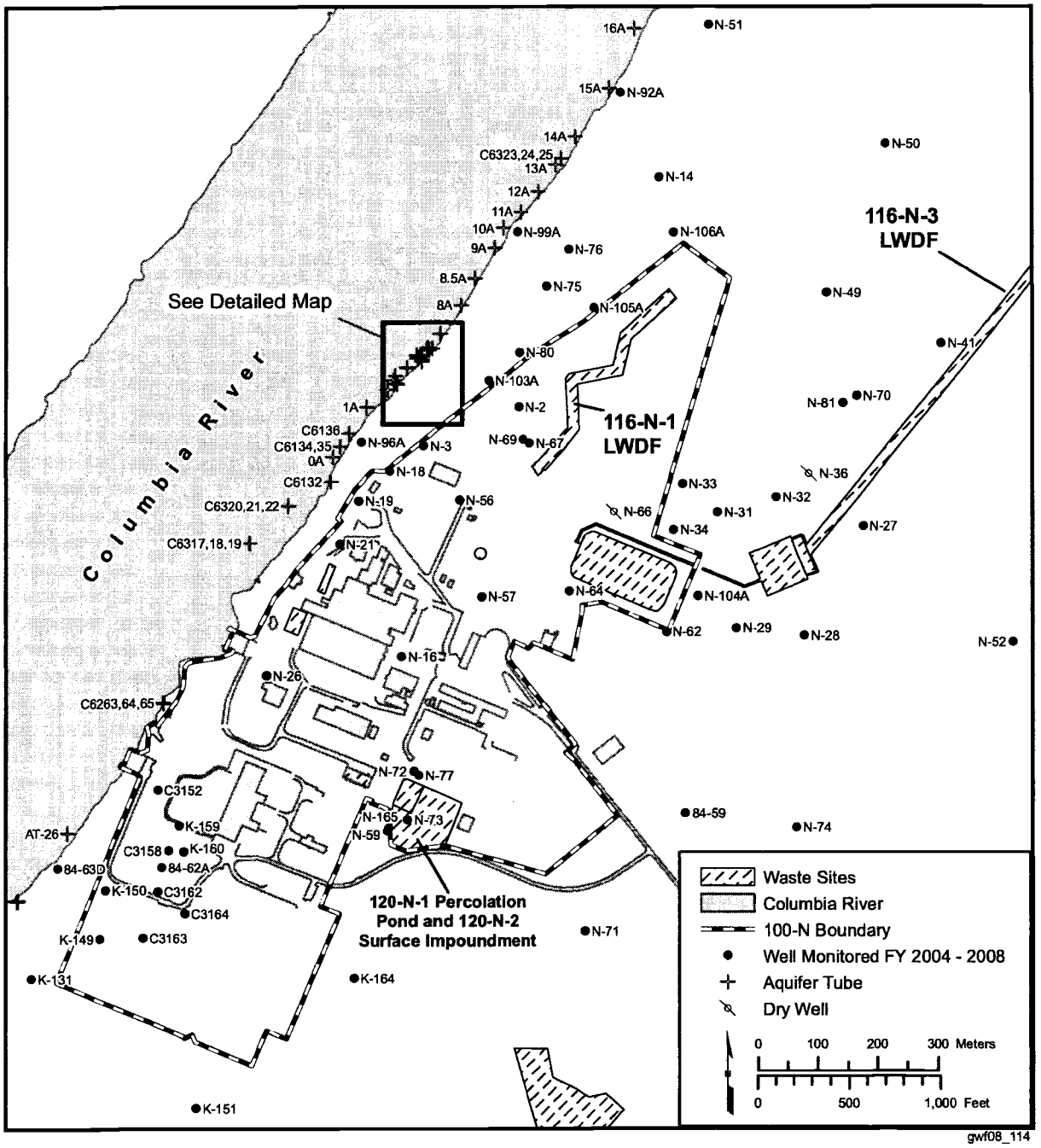


**Figure 2.4-2. Aquifer Tubes and Monitoring Wells on the 100-N Area Shoreline.**

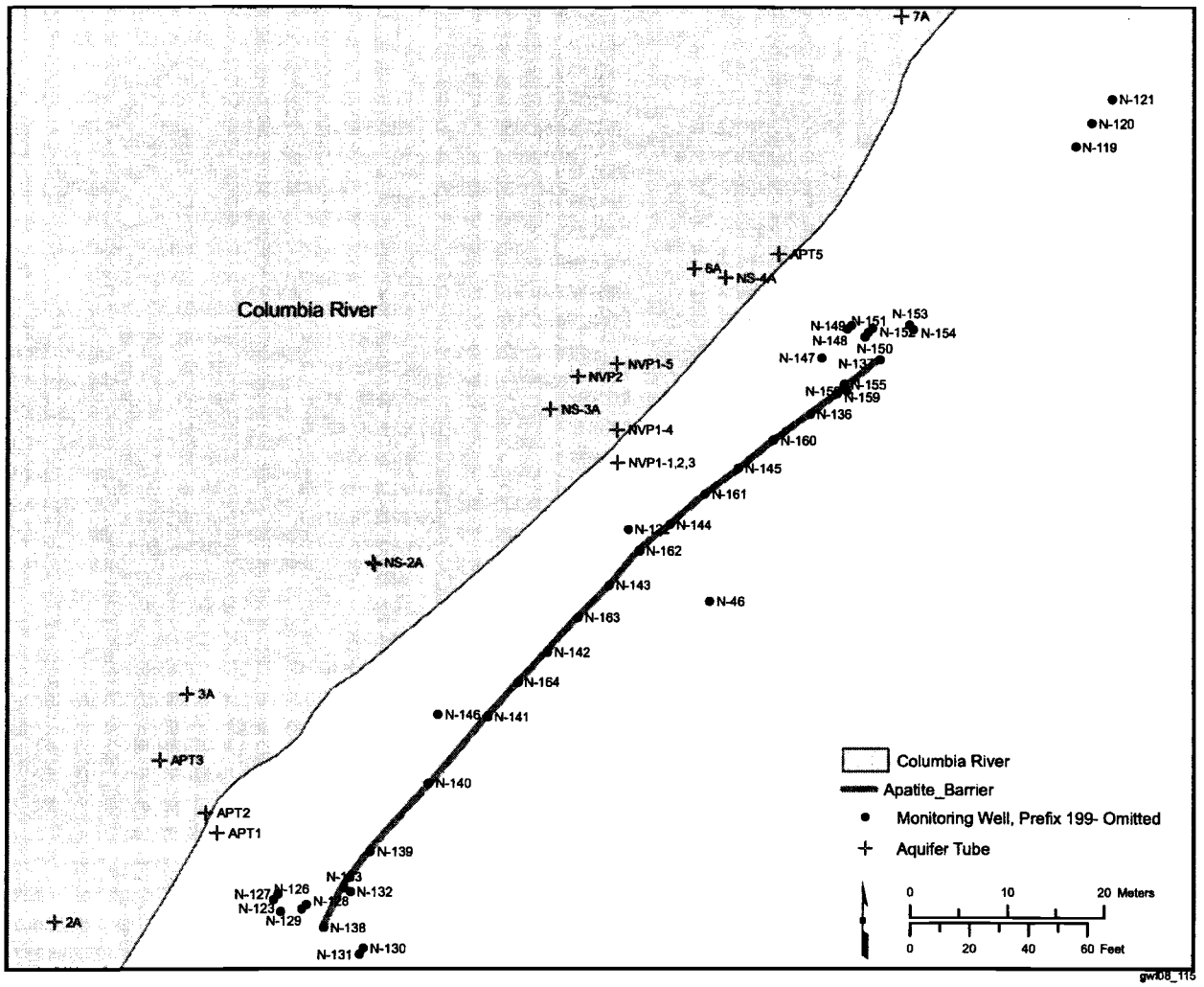


**Figure 2.4-3. 100-N Area Water-Table Map, March 2008.**

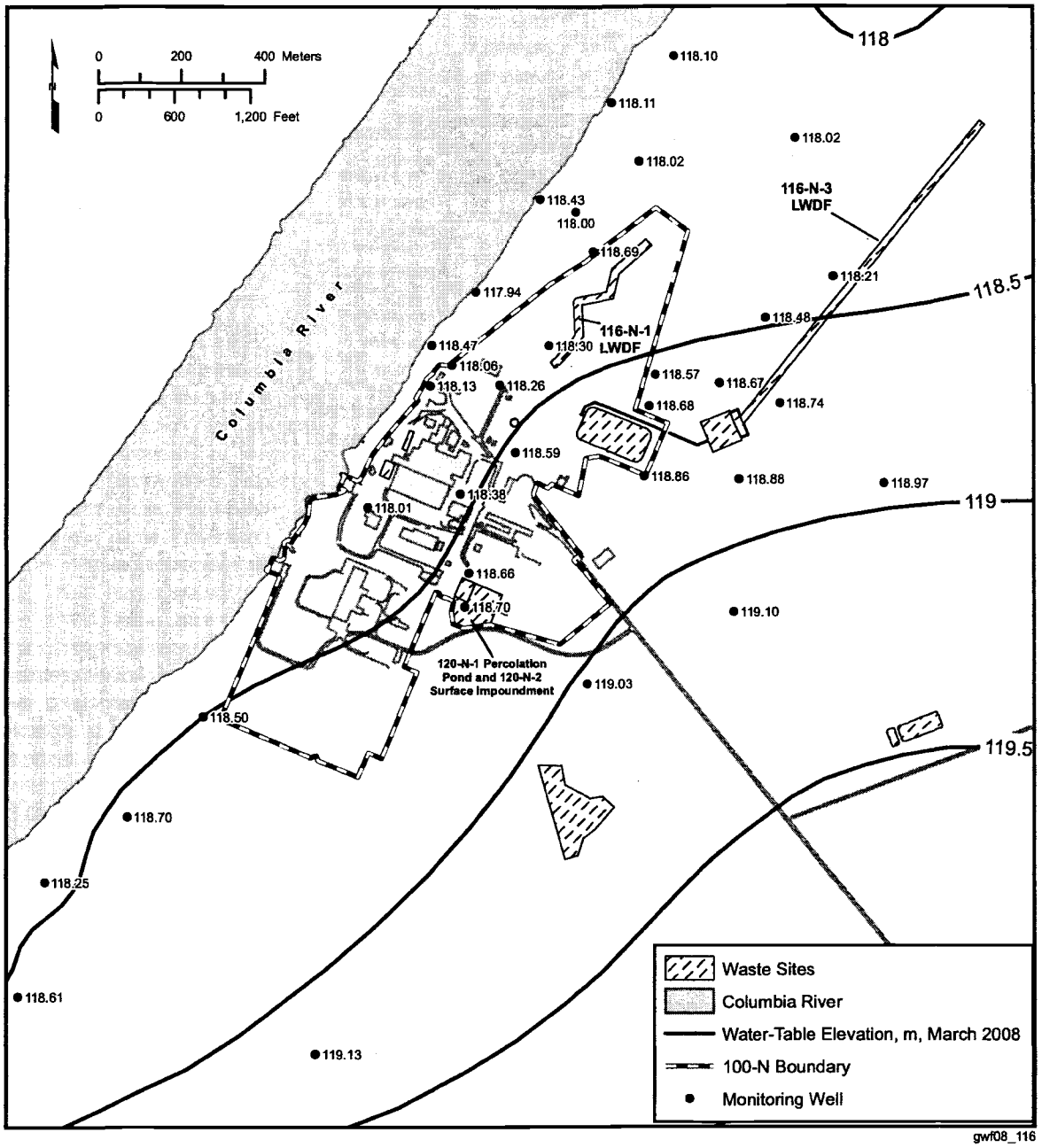


**Figure 2.4-4. Average Strontium-90 Concentrations in the 100-N Area, Upper Part of Unconfined Aquifer.**

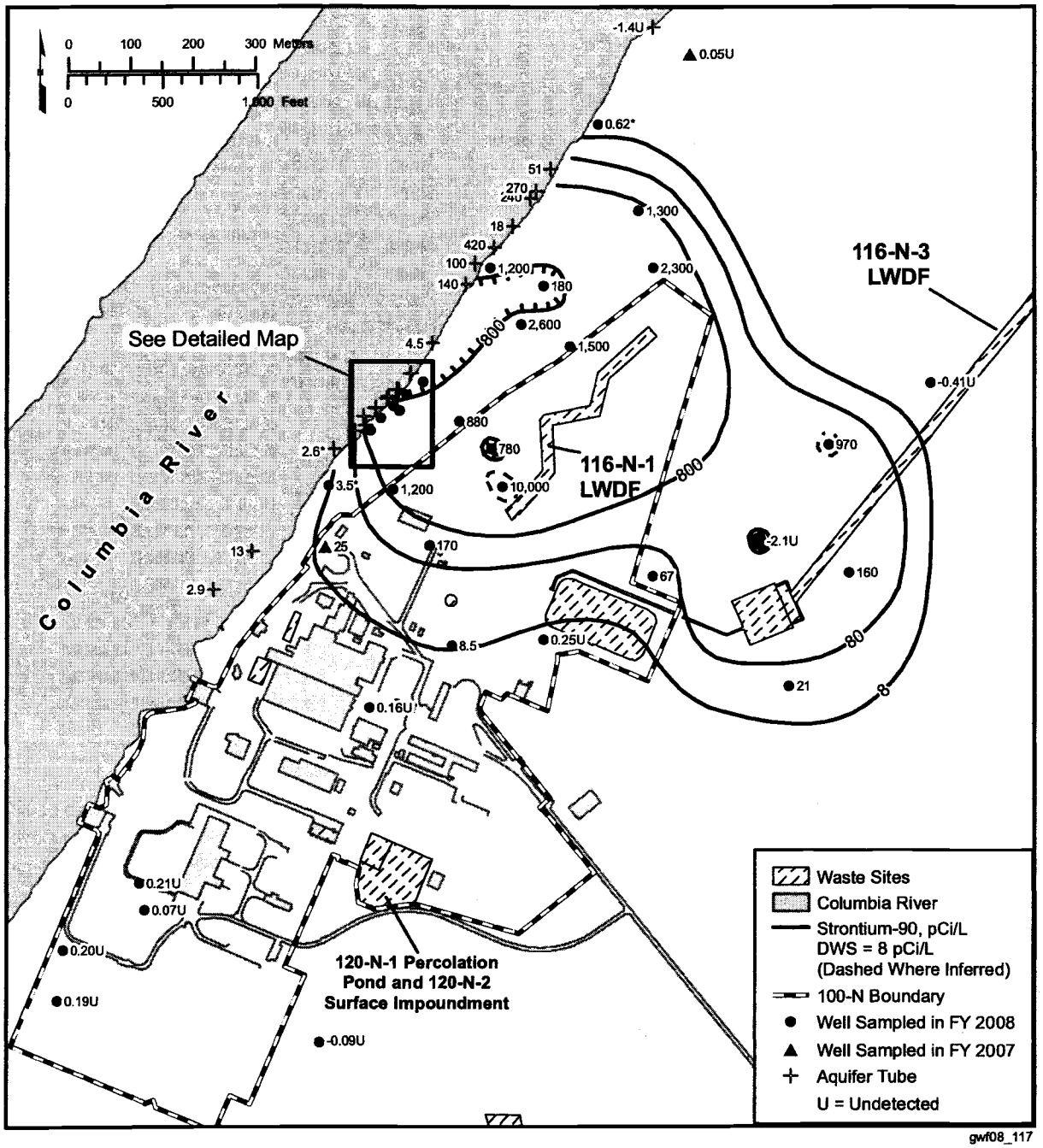


**Figure 2.4-5. Strontium-90 in Groundwater at the Shoreline Study Area, September 2008, Upper Part of Unconfined Aquifer.**

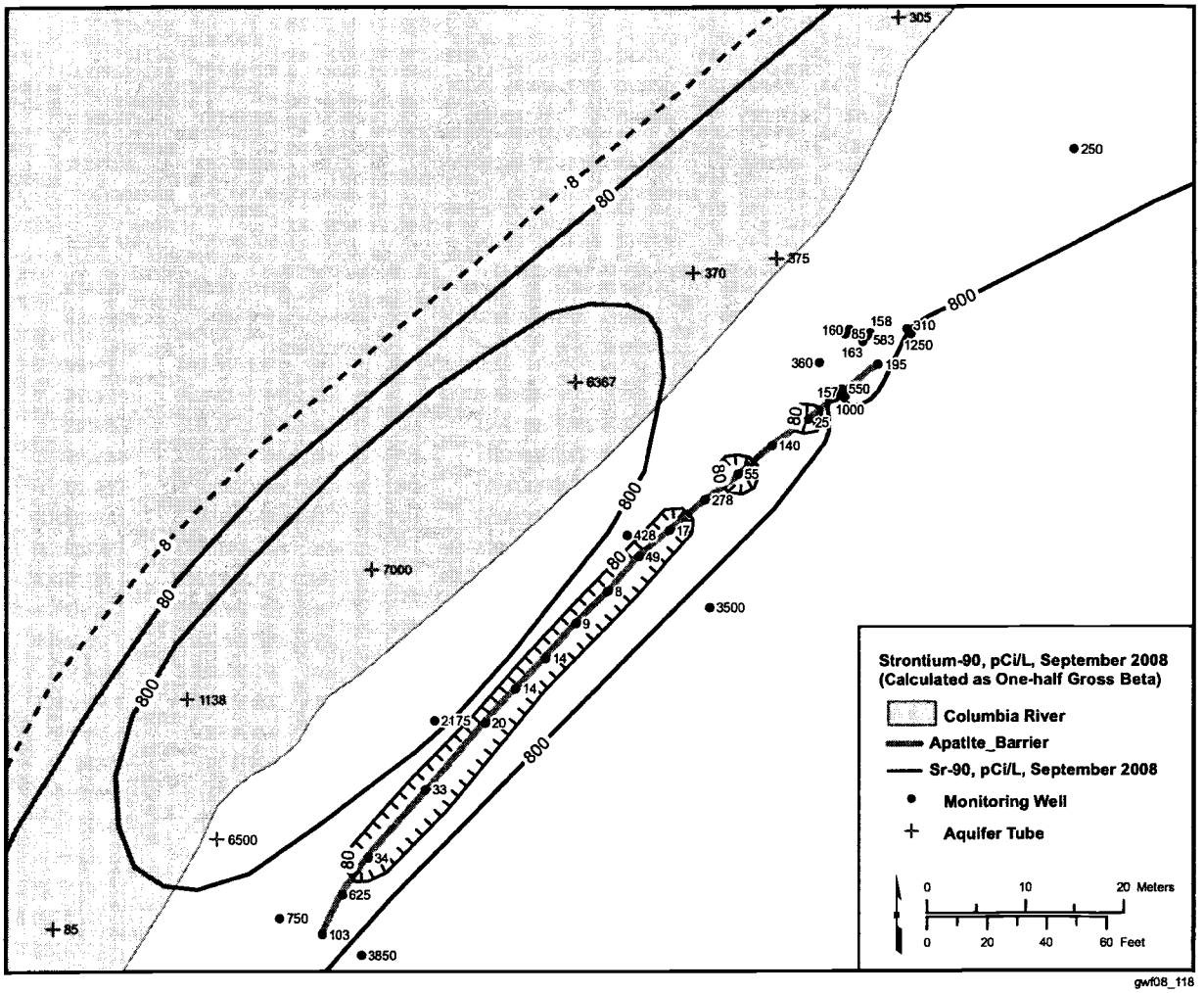


**Figure 2.4-6. Strontium-90 Concentrations and Water Levels near the 116-N-1 Facility.**

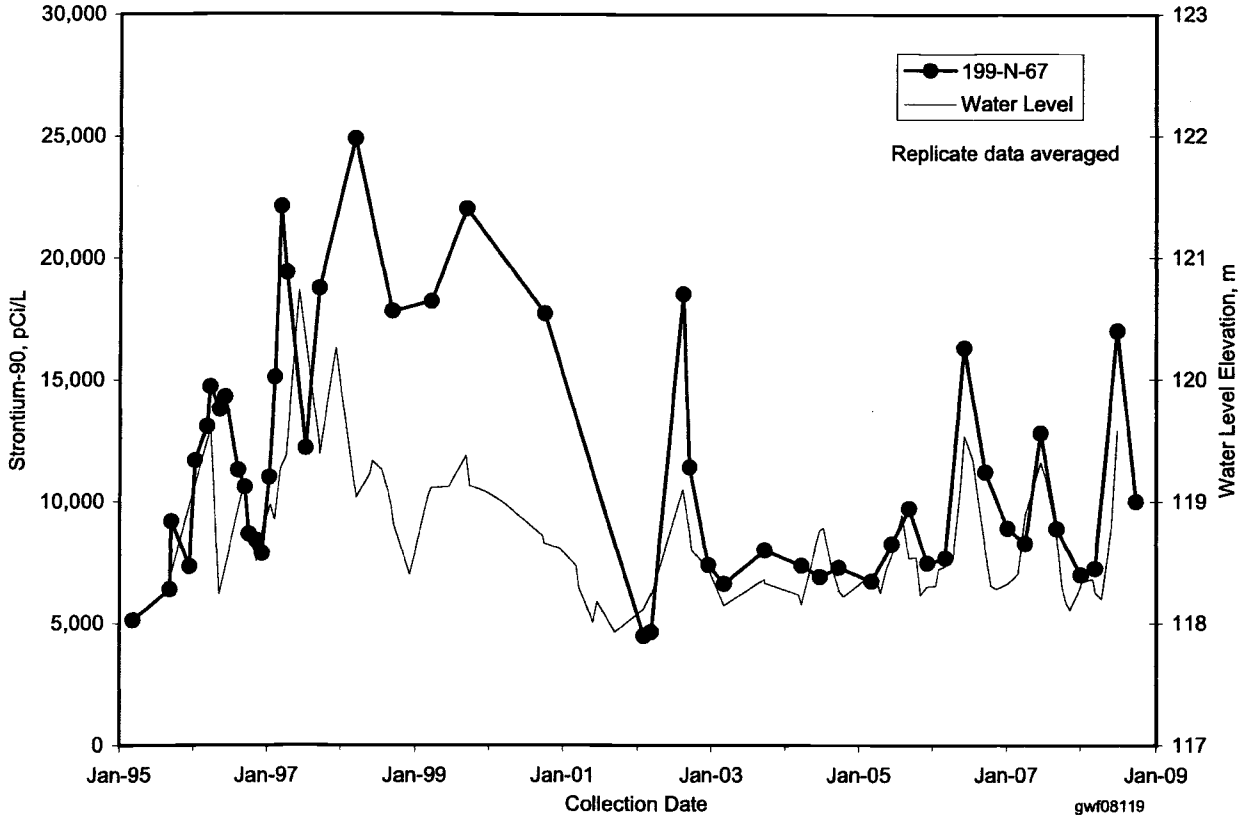



**Figure 2.4-7. Strontium-90 Concentrations and Water Levels near the 116-N-3 Facility.**

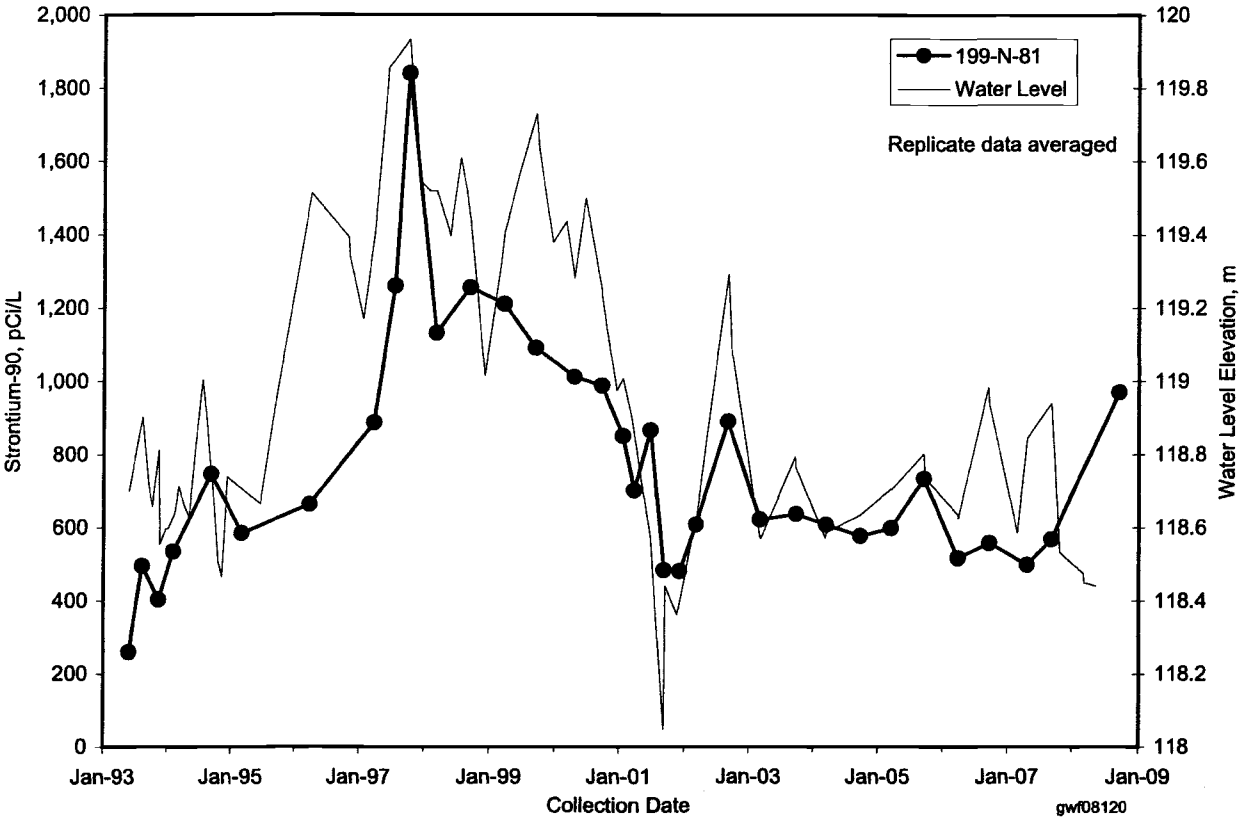


**Figure 2.4-8. Gross Beta Vertical Profile in 100-N Area Aquifer Tubes.**

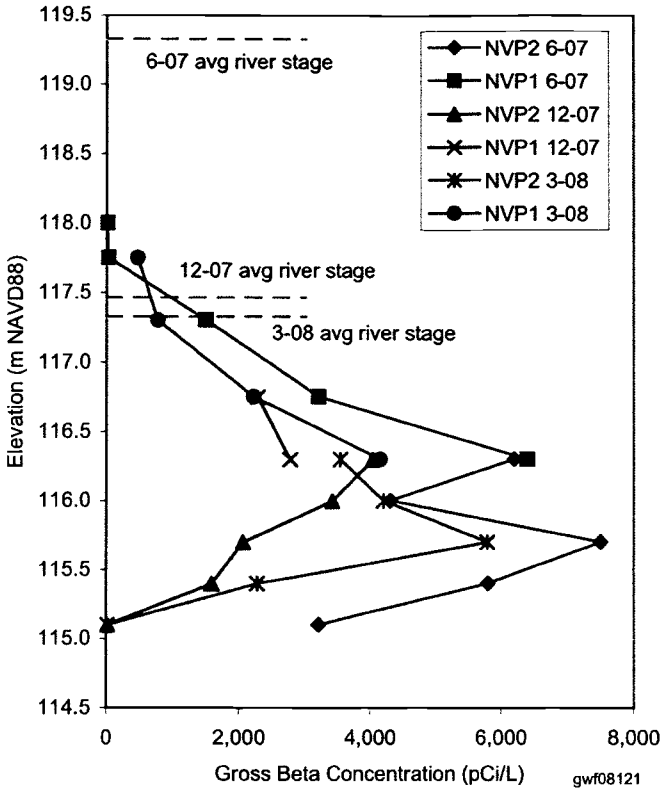



**Figure 2.4-9. Tritium Concentrations near the 116-N-1 and 116-N-3 Facilities.**

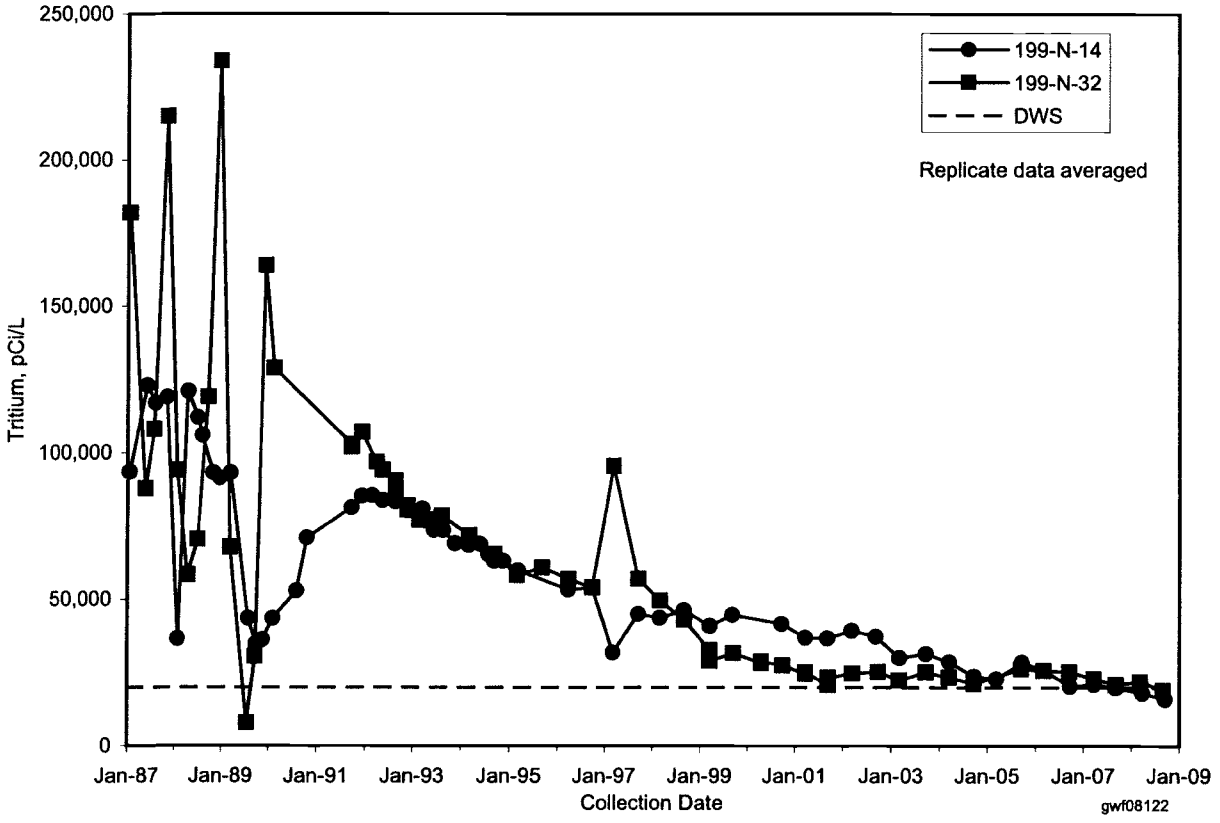


**Figure 2.4-10. Average Nitrate Concentrations in the 100-N Area, Upper Part of Unconfined Aquifer.**

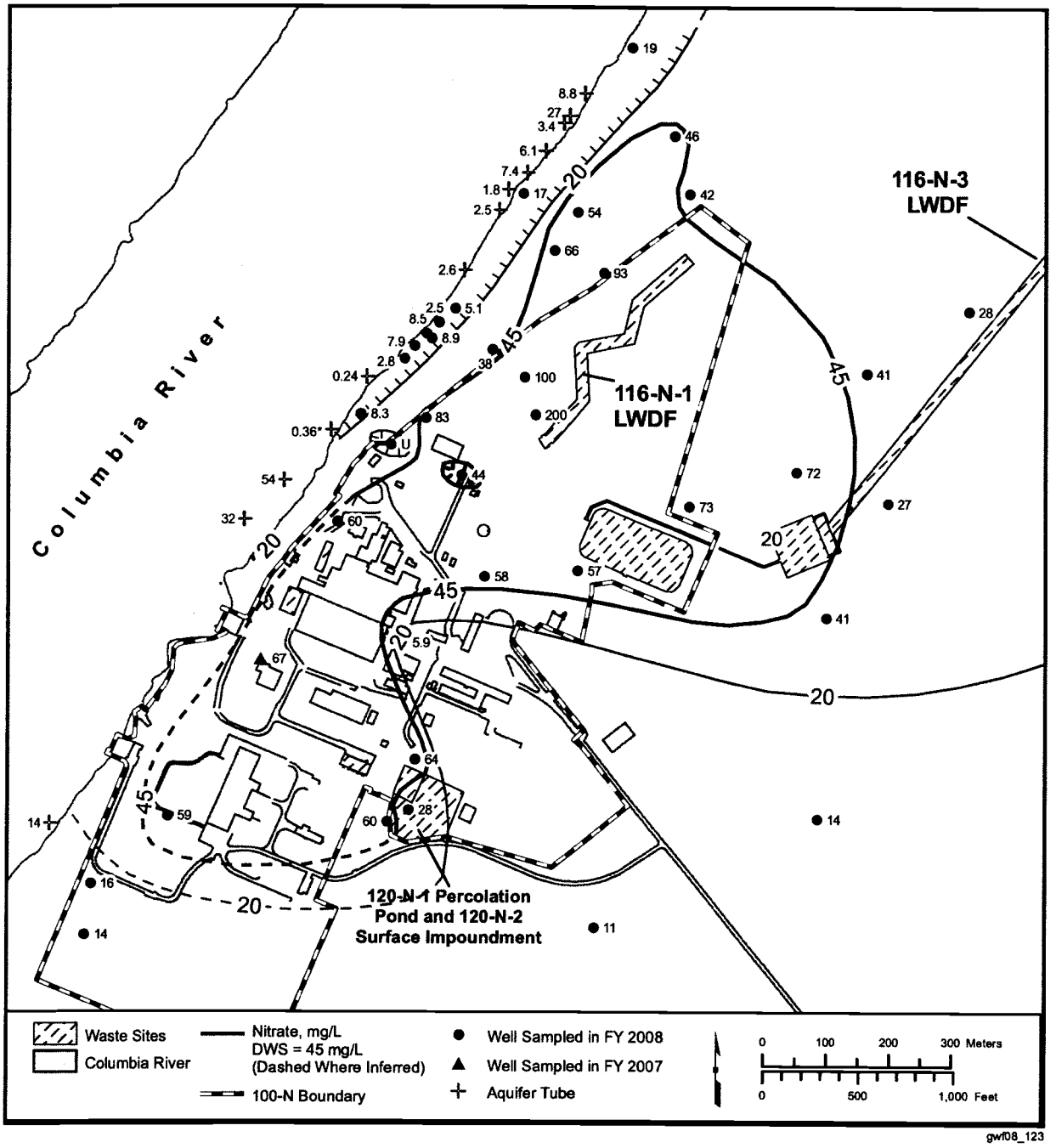


**Figure 2.4-11. Nitrate Concentrations near the 116-N-1 Facility.**

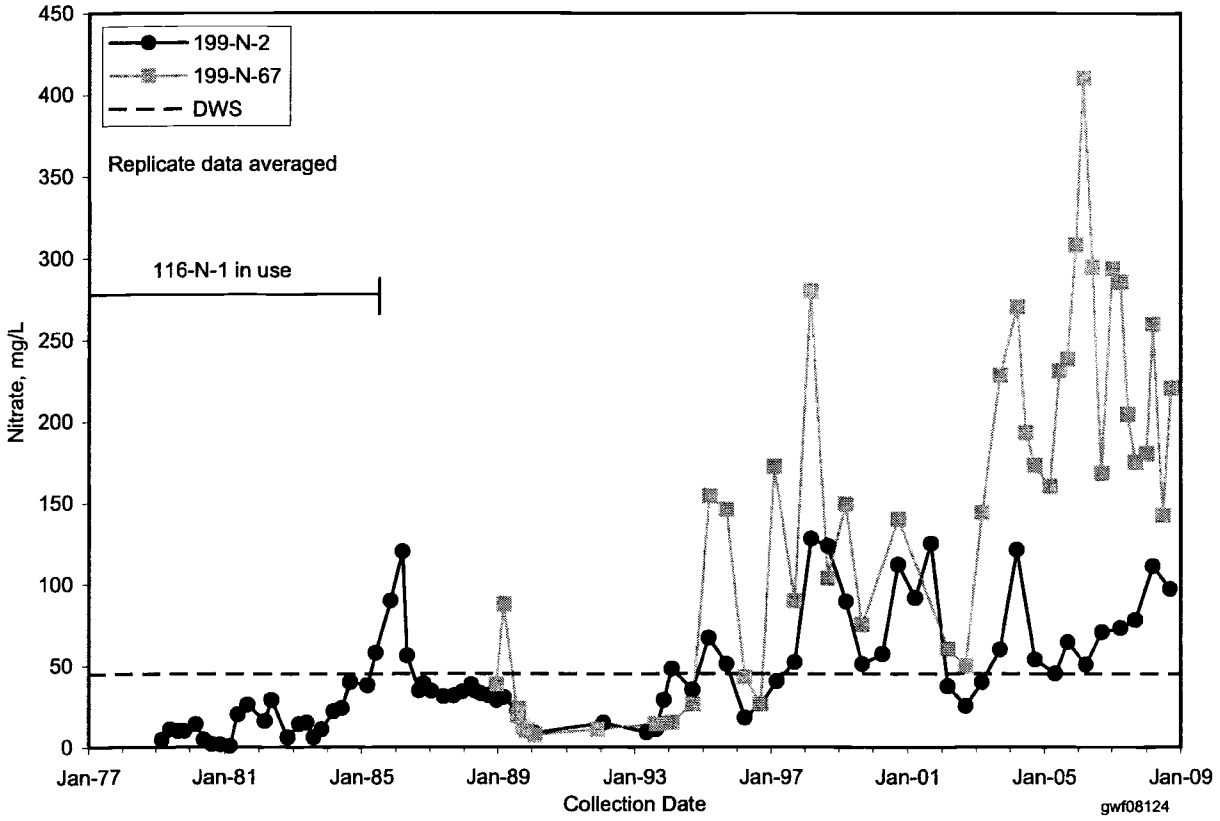



**Figure 2.4-12. Nitrate Concentrations near the 116-N-3 Facility.**

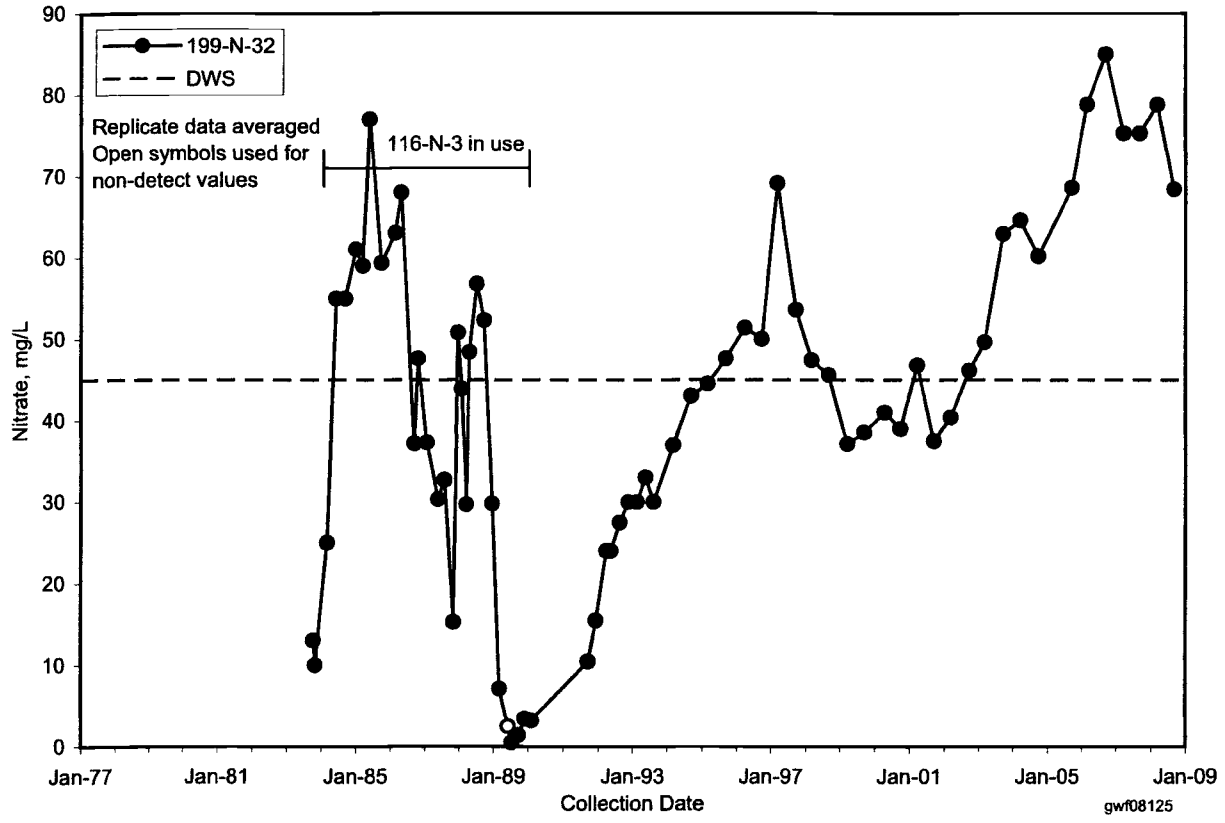


**Figure 2.4-13. Nitrate Concentrations near the 120-N-1 Percolation Pond.**

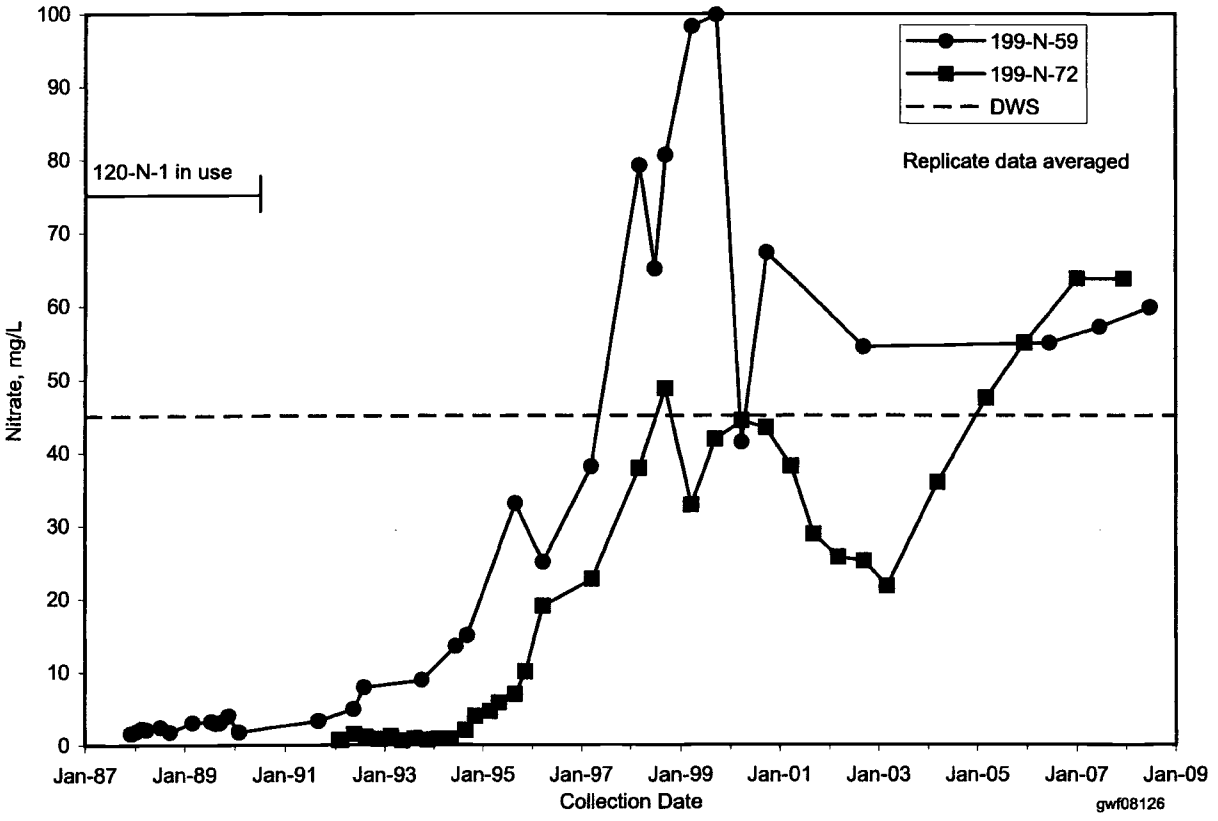



**Figure 2.4-14. Gross Beta (and Equivalent Strontium-90) Concentrations in Aquifer Tube NVP2-116.0.**

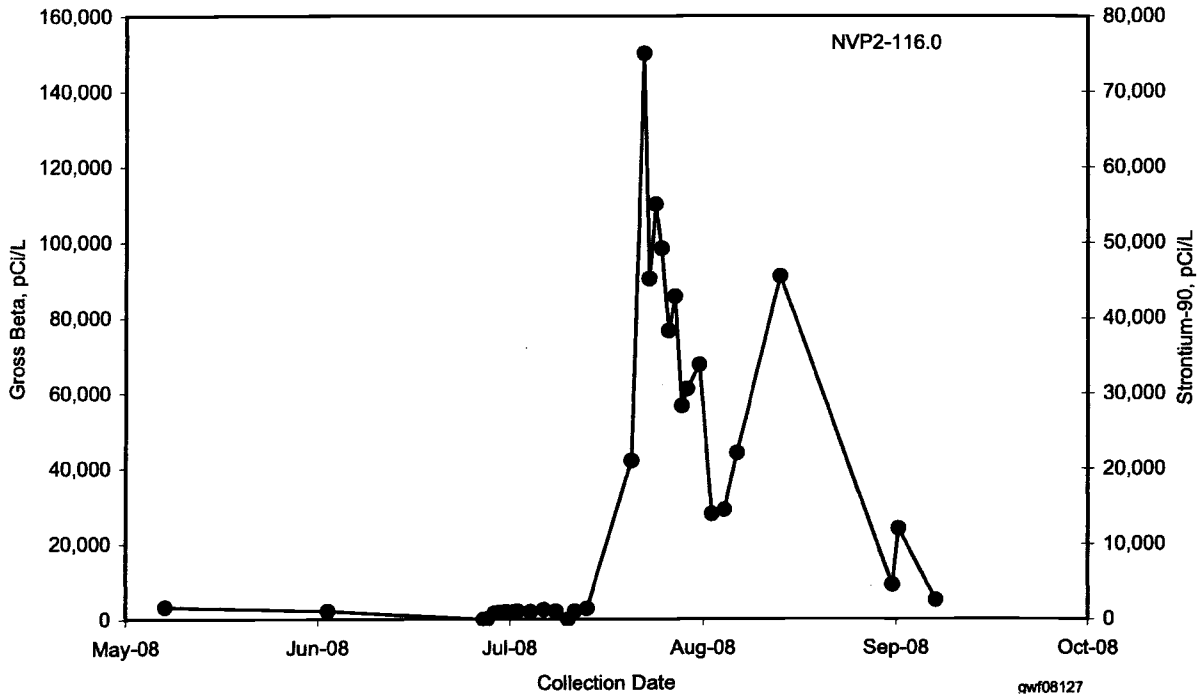


**Figure 2.4-15. Gross Beta (and Equivalent Srontium-90) Concentrations in Apatite Injection/Barrier Well 199-N-162.**

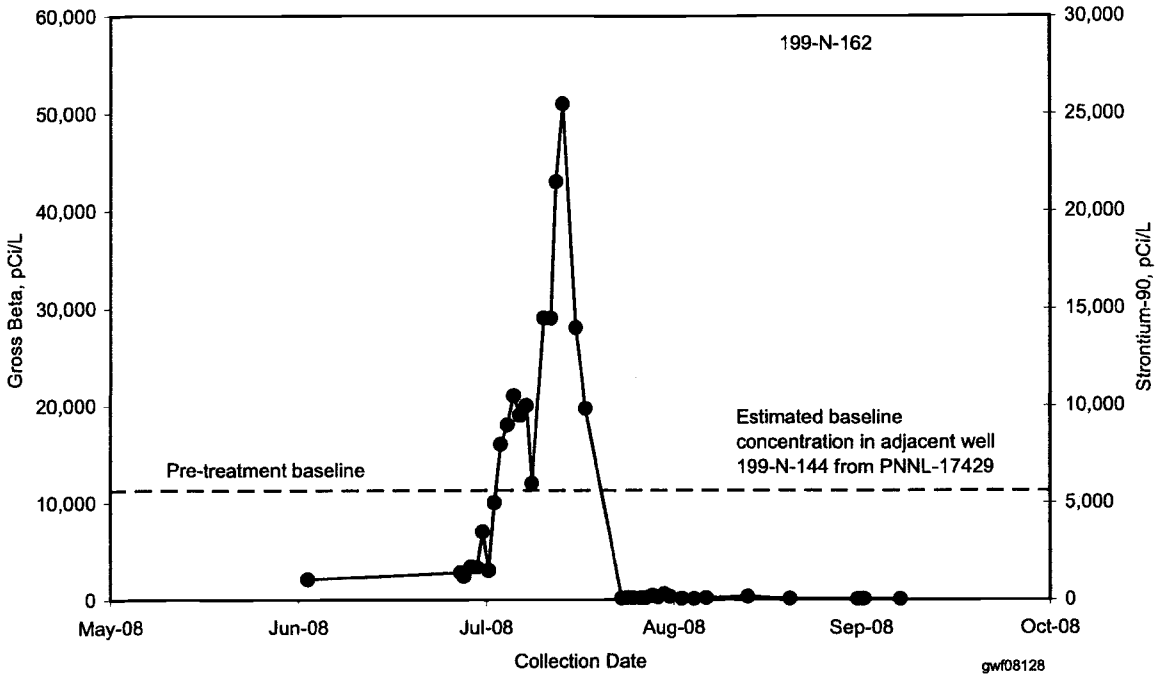
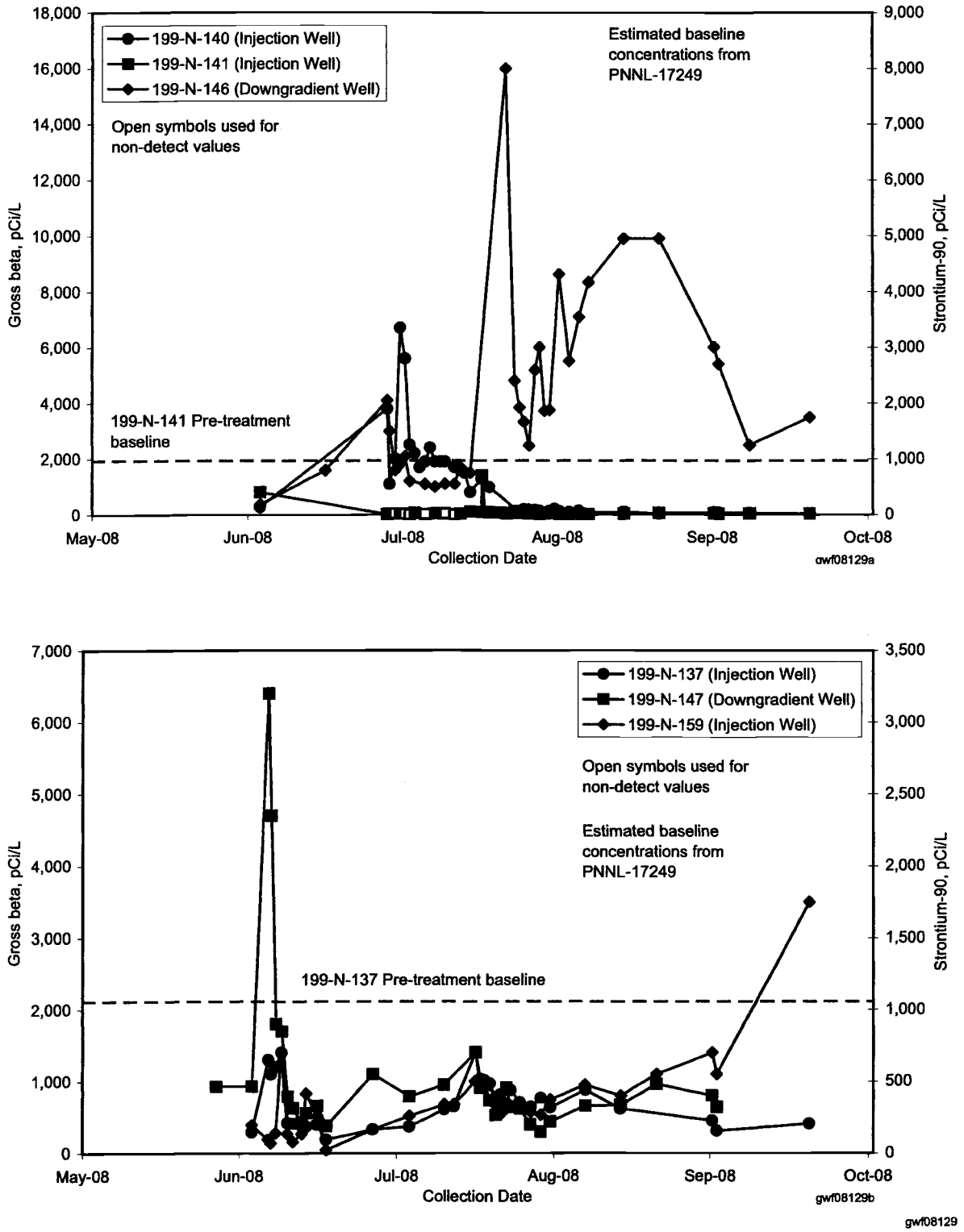


**Figure 2.4-16. Gross Beta (and Equivalent Strontium-90) Concentrations in Apatite Injection/Barrier Wells and Downgradient Monitoring Wells.**



# 2.5 100-HR-3-D Groundwater Interest Area

*M. J. Hartman*

This section describes groundwater flow and chemistry in the 100-HR-3-D groundwater interest area (including the 100-D Area located in the western portion of the 100-HR-3 Operable Unit). Figures 2.5-1 and 2.5-2 show facilities, wells, and shoreline monitoring sites in this region. Hexavalent chromium is the principal contaminant of concern in 100-D Area groundwater.

***Hexavalent chromium is the principal contaminant of concern in the 100-D Area.***

Groundwater beneath the 100-D Area flows primarily to the north and west, toward the Columbia River (Figure 2.5-3). Near the Columbia River, including the in situ reduction-oxidation (redox) manipulation site, the average flow direction is toward the northwest. Farther inland, average flow is northward. Extraction and injection of groundwater from pump-and-treat systems affect flow locally in the 100-D Area.

East of the 100-D Area, groundwater flows to the northeast, turning eastward near the 100-H Area (Figure 2.1-2). Thus, groundwater contaminants from the 100-D Area may migrate across the horn of the Hanford Site toward the 100-H Area.

Some of the main concepts associated with the 100-HR-3-D groundwater interest area include the following.

- Principal sources of groundwater contamination included liquid waste sites (trenches, cribs, and retention basins). Leaks from pipelines and spills of sodium chromate solution also contributed to groundwater contamination. The waste sites have been remediated (shallow contaminated sediment has been excavated) and backfilled.
- Recent drilling has not identified a deep vadose zone source of chromium. However, high concentrations in groundwater indicate a vadose zone source remains.
- Hexavalent chromium is the principal contaminant of concern in groundwater. The area of the plume has remained stable over the past three years.
- New wells have helped define the core of the chromium plume, with concentrations over 30,000 µg/L in some samples.
- The U.S. Department of Energy (DOE) continued characterizing the chromium plume between the 100-D and 100-H Areas. Concentrations generally range from 20 to ~100 µg/L.
- Nitrate and tritium contamination also is present in groundwater.
- Two pump-and-treat systems continued to operate in the 100-D Area. The original system removed 22.9 kg of chromium in fiscal year (FY) 2008, and 287 kg since 1997. The DR-5 Pump-and-Treat System removed 50.6 kg in FY 2008 and 211 kg since 2004. A pilot-scale system removed an additional 30 kg in the early 1990s. Concentrations in groundwater remained above the remedial action goal of 22 µg/L.
- An in situ treatment system converts hexavalent chromium to a non-toxic, immobile form within a portion of the aquifer. Concentration in some downgradient wells remained above the remedial action goal of 20 µg/L. The DOE is investigating a method of repairing the treatment system by injecting zero-valent iron.

- The DOE is testing a remediation method that stimulates bacteria in the aquifer to reduce hexavalent chromium to a non-toxic form.
- All but one of the monitoring wells are screened at the top of the unconfined aquifer, which is 3 to 9 m thick in the 100-D Area. One well is screened in the Ringold upper mud unit, and it does not detect any contamination.

The groundwater in the 100-D Area is monitored for the objectives of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) and the *Atomic Energy Act of 1954* (AEA). Section 2.5.1 describes contaminant plumes and concentrations. Section 2.5.2 summarizes operable unit activities, which include interim action groundwater remediation, chromium characterization, and testing technologies for chromium remediation and treatment. There are no active waste disposal facilities or *Resource Conservation and Recovery Act of 1976* sites in the 100-D Area.

## 2.5.1 Groundwater Contaminants

Wells in the 100-D Area are sampled for hexavalent chromium, which is the principal contaminant of concern, and co-contaminants: strontium-90, tritium, nitrate, sulfate, and gross beta. This section describes distribution and trends of those groundwater contaminants beneath the 100-D Area.

***Plume areas (square kilometers) in the 100-HR-3-D groundwater interest unit:***

***Chromium, 100 µg/L — 0.76***
***Chromium, 20 µg/L* — 2.9***
***Nitrate, 45 mg/L — 0.92***
***Tritium, 20,000 pCi/L — 0.03***

****Includes chromium plume east to boundary with 100-HR-3-H groundwater interest area.***

### 2.5.1.1 Chromium

Hexavalent chromium is the principal contaminant of concern for the 100-HR-3 Operable Unit interim actions (EPA/ROD/R10-99/039; EPA/AMD/R10-00/122). The remedial action goal is 22 µg/L for the pump-and-treat systems and 20 µg/L for the redox system.

Chromium contamination underlies most of the 100-D Area in two plumes. The northern plume likely originated from cribs and trenches in the central 100-D Area, and the southern plume has sources near the former chromate transfer station.

Figure 2.5-4 shows chromium in the entire horn of the Hanford Site, which includes the 100-D and 100-H Areas and the 600 Area between them. The plume extends from 100-D Area to 100-H Area at concentrations between 20 and ~100 µg/L. The contamination is believed to have migrated eastward from the 100-D Area when there was a groundwater mound beneath the retention basins. Section 2.5.2.4 discusses the horn chromium investigation. Figure 2.5-5 shows chromium distribution at the redox site in the southwestern 100-D Area.

***At 100-D Area, three remediation systems help reduce the amount of chromium reaching the Columbia River: two pump-and-treat systems in the north and an in situ remediation system in the southwest.***

Aquifer tubes provide additional monitoring points along the 100-D Area shoreline. Figure 2.5-6 illustrates the depths of the aquifer tubes and screened intervals of wells near the shoreline. Chromium concentrations greater than ~100 µg/L are detected in tubes from 1 to 8 m below land surface. Figure 2.5-7 shows the ranges of chromium concentrations in 100-D Area aquifer tubes over the period of monitoring. At most sites, FY 2008 concentrations were in the lower end of the historical range. The following paragraphs discuss chromium trends in more detail.

***Northern Plume.*** The ~100 µg/L contour of the northern chromium plume extends from cribs, trenches, and pipelines near the former D Reactor building toward the north and west. At concentrations between 20 and 100 µg/L, the plume

extends eastward to the 100-H Area. One well near the 100-H Area (699-97-43B) had concentrations greater than 100 μg/L for several sampling events in FY 2008.

Well 199-D5-15 is monitored near the sources of the northern plume (Figure 2.5-8). Concentrations were low in 1999 to 2003 because of dilution from nearby leaking water lines, which were repaired in 2004 (PNNL-15070). Concentrations began to increase in 2004 and reached a maximum of 2,450 μg/L in May 2007. Concentrations subsequently declined, and were ~1,000 μg/L in FY 2008. The cause of the recent spike in chromium concentrations is unknown.

Chromium concentrations also increased in wells 199-D5-14 and 199-D5-16, located downgradient of well 199-D5-15 (Figure 2.5-8). These increases may reflect movement of the FY 2007 chromium peak in well 199-D5-15.

In the northern 100-D Area near the original pump-and-treat system, compliance wells continued to show variable chromium concentrations, with the lowest concentrations in the early summer when river stage was high (Figure 2.5-9). The concentrations in compliance wells were below the 22 μg/L remedial action goal during summer 2008. The seasonal concentration peaks (fall and winter of each year) have declined since 2000. Section 2.5.2 contains more information about the pump-and-treat systems.

Chromium concentrations have decreased in extraction wells on the southwestern side of the northern plume (Figure 2.5-10) since groundwater extraction began in July 2004. Average FY 2008 concentrations in the three extraction wells were 235 μg/L in well 199-D5-20, 141 μg/L in well 199-D5-32, and 95 μg/L in well 199-D5-92. Concentrations continued declining in all three wells. In nearby monitoring well 199-D5-41, chromium concentrations declined from more than 2,000 μg/L in 2005 and 2006 to less than 20 μg/L in FY 2008 (Figure 2.5-11). The decline was not accompanied by any change in specific conductance that would indicate dilution with clean water. The decline in chromium concentrations may be caused by migration of treated water from the DR-5 Pump-and-Treat System, which is injected into well 199-D5-42 (located upgradient of well 199-D5-41).

Four of the five aquifer tube clusters monitoring the northern plume had at least one result exceeding the 10 μg/L aquatic standard in FY 2008 (Figure 2.5-6). The highest concentration was 60 μg/L in AT-36-M. This was a decrease from the FY 2007 concentration of more than 100 μg/L.

Well 199-D8-54B in the north 100-D Area monitors a silty sand unit within the Ringold upper mud unit. In this deeper, confined unit, chromium concentrations are near the detection limit, while an adjacent shallow well has concentrations above the drinking water standard.

***Southern Plume.*** This chromium plume lies south and southwest of the 182-D Reservoir and west of the 183-DR Filter Plant, extending to the Columbia River (Figures 2.5-4 and 2.5-5). The core of the chromium plume, with concentrations exceeding 1,000 μg/L, is oriented west-northwest. The redox barrier intersects the south chromium plume and terminates the highest-concentration portion of the plume.

In FY 2008, DOE installed four new wells to investigate chromium sources in the southern 100-D Area. The new wells are 199-D5-119, 199-D5-120, 199-D5-121, and 199-D5-122 (Figure 2.5-1). These wells supplement information from the seven chromium source investigation wells drilled in FY 2007. The highest levels of

***New wells in the southern 100-D Area help characterize chromium sources there. Some of the new wells have the highest chromium concentrations ever measured in Hanford Site groundwater.***

chromium in groundwater were in wells 199-D5-99 and 199-D5-104 (Figure 2.5-12). Well 199-D5-99 had a peak level of more than 30,000 µg/L in FY 2008. Section 2.5.2.7 discusses this investigation further.

Compliance monitoring wells downgradient of the redox barrier show inconsistent chromium trends (Figure 2.5-13). Northernmost well 199-D4-83 had levels exceeding 50 µg/L in FY 2008, a slight increase from FY 2007, when levels were mostly below the remedial action goal. Also near the north end of the barrier, well 199-D4-39 had much higher levels, ranging from 156 to 617 µg/L in FY 2008. However, the concentrations show an overall decline since 2004. Concentrations remained variable in well 199-D4-38, ranging from 59 to 255 µg/L. Nearby wells 199-D4-23 and 199-D4-84 had lower and less variable concentrations (19 to 62 µg/L). Most FY 2008 chromium concentrations were below the remedial action goal in the southernmost compliance wells 199-D4-85 and 199-D4-86.

Chromium concentrations remained above 100 µg/L in several wells within and downgradient of the redox barrier (Figure 2.5-5). Chromium is migrating through the barrier in some locations, and the DOE is studying alternative methods to mitigate this problem (Section 2.5.2).

Chromium concentrations downgradient of the redox site have decreased since the late 1990s in most of the aquifer tubes (Figure 2.5-14). However, concentrations increased sharply in some tubes in FY 2008 (e.g., Redox-1-6.0). The highest concentration in this region was 422 µg/L in tube Redox-1-3.3 (Figure 2.5-6) in FY 2008. This aquifer tube is located downgradient of well 199-D4-39, which has the highest chromium concentrations downgradient of the redox barrier.

Chromium concentrations in the central 100-D Area (e.g., wells 199-D5-33, 199-D5-36, and 199-D5-44) are very low. These wells separate the southern and northern chromium plumes. The low concentrations were probably caused by infiltration of clean water from the 182-D Reservoir, and injection of treated water into well 199-D5-42. Repairs and operational changes have reduced the amount of infiltration from the 182-D Reservoir, but chromium concentrations have not responded. Specific conductance remains low (~220 µS/cm or less).

### 2.5.1.2 Strontium-90

Two locations in the 100-D Area (near the former retention basins in the north and near the D Reactor building) have a history of strontium-90 detections in groundwater. Concentrations were below the 8 pCi/L drinking water standard in FY 2008.

Well 199-D8-68 (near the former retention basins) continued to have the highest strontium-90 concentration in FY 2008. Duplicate samples in November 2007 had analytical results of 5.7 and 7.7 pCi/L. Concentrations ranged from 2 to 14 pCi/L in this well since 1998.

Wells near the former D Reactor were not sampled for strontium-90 in FY 2008. Previous detections in well 199-D5-15 were ~2 pCi/L.

***Tritium contamination in the southern 100-D Area may have originated in the 100-N Area.***

### 2.5.1.3 Tritium

Tritium concentrations remained below the 20,000 pCi/L drinking water standard in most wells in the 100-D Area, but continued to exceed the standard in three wells (Figure 2.5-15) and one aquifer tube (DD-44-4) near the southern part of the redox barrier. The tritium contamination is believed to have originated as part of the 100-N Area tritium plume to the south. A peak of contamination moved past well

199-D3-2 in the late 1990s. Concentrations in this well have increased again since 2004, but remained below the drinking water standard in FY 2008.

### 2.5.1.4 Nitrate and Nitrite

Figure 2.5-16 shows the distribution of nitrate in 100-D Area groundwater. The plume has two major lobes. Nitrate concentrations continued to exceed the drinking water standard (45 mg/L) in both lobes, with a FY 2008 maximum concentration of 116 mg/L in well 199-D2-6 in the southern 100-D Area. The southern portion of the nitrate plume is intercepted by the redox barrier, which chemically reduces the nitrate. Nitrate concentrations in 100-D Area aquifer tubes were all below the drinking water standard.

Nitrite was detected in some of the wells monitoring the redox barrier in FY 2008. Only one analytical result exceeded the 3.3 mg/L drinking water standard: 5.4 mg/L in well 199-D4-36.

### 2.5.1.5 Sulfate

Sulfate concentrations remained over 100 mg/L beneath much of the southern 100-D Area. Excluding wells influenced by the redox system, concentrations were below the secondary drinking water standard (250 mg/L) in FY 2008. Past injections of sodium dithionite solution at the redox site increased sulfate concentrations to levels above the standard in the barrier and in some downgradient wells and aquifer tubes. The highest FY 2008 concentration in a barrier well was 557 mg/L in well 199-D4-78. Concentrations have declined in this well from over 1,000 mg/L in 2003. Concentrations increased to a new maximum (549 mg/L ) in downgradient well 199-D4-84. The highest concentration in an aquifer tube was 558 mg/L in DD-43-3, also a new maximum.

### 2.5.1.6 Gross Beta

Samples from several of the wells in the redox barrier are analyzed for gross beta. A few wells continued to have concentrations exceeding the 50 pCi/L drinking water standard in FY 2008. Well 199-D4-19 had the highest value (152 pCi/L). Concentrations have been declining in this well since 2003. Analysis of a previous sample from a nearby well showed that the beta is caused by potassium-40 naturally present in the injected solution (PNNL-13116, *Hanford Site Groundwater Monitoring for Fiscal Year 1999*).

## 2.5.2 Operable Unit Activities

This section summarizes CERCLA activities in the 100-D Area, including groundwater remedial actions. The DOE began work on several Environmental Management Technology (EM-22) proposals in the 100-D Area. The DOE also began characterizing a chromium plume between the 100-D and 100-H Areas.

The DOE installed eight new wells in the 100-HR-3-D groundwater interest area in FY 2008: four (199-D5-119, 199-D5-120, 199-D5-121, and 199-D5-122) for a chromium source area investigation in the 100-D Area, and four (699-95-51, 699-96-52B, 699-97-48B, and 699-98-51) to define chromium distribution east of the 100-D Area.

### 2.5.2.1 Status of CERCLA Five-Year Review Action Items

The second CERCLA five-year review was published in November 2006 (DOE/RL-2006-20). The review identified six actions pertaining to the 100-D Area.

**Action 8-1.** Complete a field study to investigate additional sources of chromium groundwater contamination within the 100-D Area. Complete additional geologic and geochemical investigations of the vadose zone in the 100-D Area (March 2009). Progress is underway (Sections 2.5.2.7 and 2.5.2.8).

**Action 9-1.** Perform additional characterization of the aquifer in the horn and evaluate the need to perform remedial action to meet the remedial action objectives of the 100-D Area record of decision for interim action (September 2009). Progress is underway (Section 2.5.2.4). Figure 2.5-4 illustrates chromium distribution across the horn.

**Action 9-2.** Incorporate the horn into the 100-HR-3 interim action record of decision if Action 9-1 indicates the horn contains a plume that needs immediate remediation (September 2009). This action depends on the outcome of Action 9-1 and will be incorporated into the systematic planning process and remedial process optimization for the 100-HR-3 Operable Unit.

**Action 10-1.** Direct the operating contractor to further minimize leaks from the 182-D Reservoir (previously completed).

**Action 11-1.** Initiate limited iron amendments to evaluate whether this enhances redox barrier performance (September 2007). Testing is ongoing, with results expected in FY 2009 (Section 2.5.2.5).

**Action 11-2.** Expand groundwater pump-and-treat extraction within the 100-D Area by 378.5 L/min to enhance remediation of the chromium plume (no due date). The DOE and the lead regulatory agency have agreed that this action will be resolved through continuing improvements to the pump-and-treat system. Currently, the DOE is evaluating remedial process optimization of the pump-and-treat system and bioremediation technologies for the vadose zone. The DOE plans to install additional extraction and injection wells in FY 2009 as part of the remedial process optimization.

***The following are remedial action objectives of the 100-HR-3 Operable Unit (EPA/ROD/R10-99/039; EPA/AMD/R10-00/22).***

- ***Protect aquatic receptors in the river bottom from contaminants in groundwater entering the Columbia River.***
- ***Protect human health by preventing exposure to contaminants in the groundwater.***
- ***Provide information that will lead to the final remedy.***

***The contaminant of concern is hexavalent chromium. The records of decision specify an interim action goal of 22 µg/L at compliance wells for the pump-and-treat systems and 20 µg/L for the redox system.***

### 2.5.2.2 Pump-and-Treat Systems

Two pump-and-treat systems continued to operate to remediate chromium contamination in the 100-D Area in FY 2008. The DOE plans to expand and optimize the systems beginning FY 2009.

A pump-and-treat system in the northern 100-D Area includes four extraction wells located near the former 116-D-7 and 116-DR-9 Retention Basins. The system began operating in July 1997 with two extraction wells (199-D8-53 and 199-D8-54A). In May 2002, wells 199-D8-68 and 199-D8-72 were converted to additional extraction wells.

Extracted groundwater is transferred via pipeline to the 100-H Area where it is treated and injected into the aquifer. Monitoring requirements for this system are included in DOE/RL-96-90, *Interim Action Monitoring Plan for the 100-HR-3 and 100-KR-4 Operable Units* (as modified by DOE/RL-96-84). Long-term monitoring requirements in the 100-D Area were derived from Tri-Party Agreement Change Control Form 107. Appendix A lists wells, constituents, and sampling frequencies for interim action monitoring. For interim action monitoring, all wells were sampled as planned. For long-term operable unit monitoring, some monthly and quarterly samples were missed because of scheduling conflicts and some constituents were not scheduled for analysis. The monitoring plan for the 100-HR-3 Operable Unit is being revised.

A second pump-and-treat system (DR-5) began operating at the end of July 2004 to treat increasing hexavalent chromium concentrations in the wells southwest of the original pump-and-treat system. The system was modified in FY 2005 to increase the rate of remediation and enlarge the capture zone. From August 2005 to present, the extraction wells have been 199-D5-20, 199-D5-32, 199-D5-39, and 199-D5-92. The extracted water is treated in the 100-D Area at the DR-5 Treatment Facility, using an ion exchange system with onsite ion regeneration. The treated water is injected into well 199-D5-42.

***During FY 2008, two pump-and-treat systems in the 100-D Area removed 73.5 kg of hexavalent chromium from the aquifer.***

As of September 30, 2008, the 100-D Area Pump-and-Treat Systems had removed over 527 kg of hexavalent chromium from groundwater. Table 2.5-1 lists the mass of chromium removed by each system. The total hexavalent chromium in the north plume has been estimated at 590 kg (DOE/RL-94-957, *Hanford Sitewide Groundwater Remediation Strategy*). That estimate did not include the chromium plume in the southern 100-D Area nor in the vadose zone.

**Table 2.5-1. Mass of Chromium Removed by 100-D Area Pump-and-Treat Systems.**

| | Original Pump-and Treat System | | DR-5 Pump-and-Treat System | | Pilot-Scale Pump-and-Treat System | Total | |
|---|---|---|---|---|---|---|---|
| | FY 2008 | Since 1997 | FY 2008 | Since 2004 | 1992 to 1994 | FY 2008 | Since 1992 |
| Mass of chromium removed (kg) | 22.9 | 286.6 | 50.6 | 210.7 | 30 | 73.5 | 527.3 |

In FY 2008, chromium concentrations remained elevated in 100-D Area groundwater, although concentrations have declined since 2003 in compliance wells[1] 199-D8-69 and 199-D8-70 (Figure 2.5-9). Chromium concentrations vary inversely with river stage and have remained above the 22 µg/L remedial action goal, with the exception of readings during summer months when river stage is high. Chromium in the vadose zone appears to be a continuing source of contamination on the inland portion of the plume.

DOE/RL-2008-05 presents results of operational monitoring and additional details about the pump-and-treat systems. Results for calendar year 2008 will be included in an upcoming report on the 100 Area Pump-and-Treat Systems.

1 Certain monitoring wells are designated as "compliance wells" in the interim action record of decision. Chromium concentrations in samples from these wells are compared to the remediation goal (22 µg/L for the 100-D Area Pump-and-Treat Systems, and 20 µg/L for the redox system) to determine if the remedial action is effective.

### 2.5.2.3 In Situ Redox Manipulation System

This treatment system uses a change in redox potential to reduce dissolved hexavalent chromium in groundwater to trivalent chromium, a much less soluble and less toxic form. Objectives of the redox interim action are the same as for the 100-D Area Pump-and-Treat Systems, except that the remedial action goal for chromium at the redox site is 20 µg/L. Remedial action monitoring is described in DOE/RL-99-51, *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 Groundwater Operable Unit In Situ Redox Manipulation.* Seven wells were sampled less frequently than planned in FY 2009 (Appendix A). Some monthly and quarterly samples were not collected because of conflicts in scheduling field staff.

***The redox system has reduced chromium concentrations in the aquifer near the Columbia River.***

The redox treatment zone is ~680 m long, aligned parallel to the Columbia River, and ~100 to 200 m inland. The treatment zone is designed to reduce the concentration of hexavalent chromium in groundwater to no more than 20 µg/L at seven compliance wells situated between the treatment zone and Columbia River. The system has lowered chromium concentrations in the aquifer near the Columbia River, as shown in the chromium plume maps of Figures 2.5-4 and 2.5-5. In FY 2008, the 20 µg/L goal continued to be met[2] at two of the seven compliance wells: 199-D4-85 and 199-D4-86 (Figure 2.5-13). Levels in wells 199-D4-23, 199-D4-83, and 199-D4-84 are fairly stable in the tens of micrograms per liter. Chromium concentrations in compliance wells 199-D4-38 and 199-D4-39 continued to be variable in the hundreds of micrograms per liter.

In FY 2008, chromium concentrations continued to be elevated and variable in some of the redox barrier wells. Figure 2.5-17 shows the FY 2008 ranges of chromium concentration in the nine barrier performance-monitoring wells. Most of the elevated concentrations are in the northeastern half of the barrier. Concentrations in August 2008 were near the bottom of the year's range. The DOE is investigating methods to mitigate the chromium breakthrough using the remedial process optimization strategy (Sections 2.5.2.5 and 2.5.2.9).

Dissolved oxygen is monitored in samples from barrier wells, downgradient wells, and aquifer tubes. The lowest concentration in a well downgradient of the barrier was 0.82 mg/L in well 199-D4-84. Concentrations in this well have remained less than 4 mg/L since 2005. Most of the aquifer tubes have dissolved oxygen concentrations above 5 mg/L. The lowest concentration in FY 2008 was 3.6 mg/L in Redox-2-6.0.

***In FY 2008, the DOE continued investigating chromium contamination across the horn of the Hanford Site. Data from new wells confirm that contamination extends from the 100-D Area to the 100-H Area.***

Results of water-level monitoring within the 182-D Reservoir showed no discernible leaks in FY 2008. Reservoir leaks were identified as an issue in the CERCLA five-year review (Section 2.5.2.1).

DOE/RL-2008-10, *In Situ Redox Manipulation (ISRM) Annual Report for Fiscal Year 2007,* provides results of operational monitoring. Results for FY 2008 will be presented in an upcoming report.

### 2.5.2.4 Chromium Investigation in the Horn

***D.C. Weekes***

The DOE continued a field study to characterize the extent, concentration, and movement of hexavalent chromium in groundwater underlying the horn of the Hanford Site, between the 100-D and 100-H Areas. SGW-33224, *Sampling and*

2 The FY 2008 average of filtered, total chromium, and hexavalent chromium.

*Analysis Instructions for Investigating Chromium Groundwater Contamination in the 600 Area Between 100-D and 100-H,* provides the sampling and analysis instructions for the study.

In early FY 2008, the DOE installed fifteen wells and eighteen aquifer tubes in the horn area. A summary report (SGW-36749, *Borehole Summary Report for the Installation of Wells in the 600 Area Between 100-D and 100-H for the 100-HR-3 Groundwater Operable Unit, Fiscal Year 2007 and 2008*) of the wells installed in FY 2007 and FY 2008 was issued in April 2008.

Hexavalent chromium analyses from the new wells indicate continuous contamination across the horn between the 100-D and 100-H Areas at levels above the 22 µg/L remedial action goal but below the drinking water standard (Section 2.5.1.1 and Figure 2.5-4). Water samples collected from the semiconfined aquifer within the Ringold upper mud unit generally showed hexavalent chromium concentrations below the remedial action goal (Section 2.6.1.1).

Results of the investigation will be published in FY 2009.

***The DOE continued studying chromium contamination and remediation in the 100-HR-3 Operable Unit. Some of the special studies included injecting zero-valent iron, delineating the source area, and testing in situ biostimulation.***

### 2.5.2.5 Zero-Valent Iron Injection

***S. W. Petersen***

As part of the DOE's EM-22 program, nanometer-size iron particles are being tested for the ability to be injected into the redox wells and react with groundwater to reduce chromium from the hexavalent to the trivalent form. Zero-valent iron has been used to remediate groundwater contaminated with a wide range of chlorinated compounds (Wilkin et al., 2005, "Chromium-removal Processes during Groundwater Remediation by a Zerovalent Iron Permeable Reactive Barrier") because it is a strong chemical reductant. For the redox barrier, zero-valent iron is particularly advantageous because it is a much stronger reductant than the naturally-occurring ferrous iron (valence of +2).

In August 2008, zero-valent iron was injected into redox barrier well 199-D4-26. The purpose was to test the feasibility of augmenting iron in a portion of the barrier that had been losing its reductive capacity. Approximately 340,000 L of 1% zero-valent iron solution was injected into the full thickness of the aquifer, permeating it more than 3 m laterally from the injection well. Initial results showed that the treatment reduced hexavalent chromium to trivalent in the aquifer. Samples from the wells surrounding and downgradient from well 199-D4-26 are being collected monthly, and will be analyzed for field parameters, hexavalent chromium, metals, and anions. Results of the test will be published in FY 2009.

### 2.5.2.6 Electrocoagulation Tests

***S. W. Petersen***

As part of the DOE's EM-22 program, electrocoagulation testing was conducted as an alternative to ion exchange for treating chromium-contaminated groundwater. Electrocoagulation is a water treatment process that has been used to remove a variety of suspended solids and dissolved contaminants from water by applying an electric field to steel plates. The electric field liberates iron and causes the contaminants to precipitate, forming a solid that can be removed and disposed. The test extracted water from wells 199-D5-13 and 199-D5-41, and injected it into wells 199-D5-106 or 199-D5-33 after treatment.

The performance objective for the treatability study was to determine the effectiveness of hexavalent chromium removal from the groundwater, with a performance goal of no more than 20 µg/L in the effluent. Influent and effluent total chromium and hexavalent chromium data were collected frequently during the test. The system effectively treated water in one pass through the system, but it often had to be operated in recycle mode to achieve the performance goal. The treatability study data suggest that the electrocoagulation technology has the potential to meet the performance goal for groundwater treatment at the Hanford Site. However, system operation during the test was problematic and required constant surveillance.

### 2.5.2.7 Chromium Source Area Investigation

***S. W. Petersen***

Chromium concentrations in both 100-D Area plumes have not declined significantly, indicating that chromate is still present in the vadose zone. Chromium concentrations are above 1,500 µg/L in both plumes and have been above 12,000 µg/L in some areas. These high concentrations confirm that the source was not reactor cooling water, but a considerably more concentrated solution.

Two projects funded by the DOE's EM-22 program are helping delineate the source area of each plume. The southern plume investigation was completed in FY 2008, after installing new wells and monitoring groundwater for several months. The DOE plans to begin investigation of the northern plume in FY 2009.

The principal objective of the southern plume investigation has been to locate the source of hexavalent chromium in the southwestern contaminant plume of the 100-D Area. Drilling has been ineffective in locating a vadose zone source. While evidence of leaks or spills has been discovered within a few meters of ground surface, and many of these sites have been remediated, a deep vadose zone source for the groundwater plume has not been identified.

***Drilling has not identified a deep vadose zone source of chromium in the southern 100-D Area.***

During the chromium source investigation, no significant hexavalent chromium was found in the 147 vadose zone samples analyzed, but high concentrations were found in the groundwater. A groundwater sample from well 199-D4-99 yielded a hexavalent chromium concentration of 39,900 µg/L, the highest value detected in Hanford Site groundwater. This well was drilled near the sodium dichromate transfer facility, where highly concentrated sodium dichromate was pumped from rail cars into an underground transfer line for distribution to water treatment facilities.

An automated water-level monitoring system measured groundwater levels in selected wells every hour. These data were evaluated in conjunction with the chromium data to evaluate the movement of groundwater in the area. During one year, the groundwater flow direction varied by ~360° as indicated by particle tracking. The net movement was ~12 m/yr to the west-northwest. This is consistent with chromium concentrations in the groundwater samples, which show that the peak-measured concentration has moved, and has been found in wells 199-D5-99, 199-D5-104, and 199-D5-122.

The field data collected for this study do not reveal if a significant or active contaminant reservoir remains in the vadose zone, nor do the data reveal the surface or near-surface location of an original leak or spill of sodium dichromate. Concentration data suggest that wells 199-D5-99, 199-D5-104, 199 D5-122, and 199-D5-119 represent the margins of the high concentration zone. Current information indicates

that these four wells define the location where hexavalent chromium entered or continues to enter the aquifer.

### 2.5.2.8 Chromium Vadose Zone Characterization and Geochemistry

In FY 2007 and FY 2008, a study of chromium geochemistry was conducted as part of the DOE's EM-22 program. The following information is summarized from PNNL-17674, *Geochemical Characterization of Chromate Contamination in the 100 Area Vadose Zone at the Hanford Site.*

The primary objectives of the study were as follows.

- Determine the leaching characteristics of hexavalent chromium from contaminated sediments collected from 100 Area spill sites.
- Identify mineral or chemical factors that may be responsible for chromium retention in sediments.
- From these data, construct a conceptual model of hexavalent chromium geochemistry in the 100 Area vadose zone.

A series of column experiments were conducted with contaminated and uncontaminated sediments from the 100-B/C and 100-D Areas. The study made the following conclusions.

- Most of the hexavalent chromium traveled quickly through the sediments and appeared as hexavalent chromium in the effluents.
- The hexavalent chromium concentration remained above the drinking water standard (100 µg/L) for many pore volumes. The significance of this for groundwater concentrations would depend on the amount of recharge to the water table.
- Adsorption of hexavalent chromium to sediments was low. Very little retardation occurred.
- With a strong reductant such as calcium polysulfide solutions, hexavalent chromium reduced only partially to trivalent. However, a significant amount of the hexavalent chromium was mobilized ahead of the polysulfide solution. The experiments suggest that a remedial measure using infiltration of liquid reductant in the vadose zone would be difficult to design without increasing transport of hexavalent chromium toward the water table.
- The microscopic characterization results were consistent with the column studies. Hexavalent chromium coated sediment grain surfaces. Small, higher concentration chromium sites were associated with certain types of mineral inclusions. Hexavalent chromium was reduced to trivalent chromium in association with iron oxides.
- Results indicated that at least four leaching behaviors are present in the tested contaminated sediments.
    - The first type contained over 95% of the hexavalent chromium. It was in a highly mobile form that was easily removed from the contaminated sediments in the first pore volumes of leaching experiments.
    - The second type represents hexavalent chromium material held in physical and mineralogical sites that provide a longer-term source.

***Over 95% of the hexavalent chromium in the vadose zone is highly mobile.***

- The third type consists of reduced trivalent chromium, most likely by redox reactions with iron-bearing soil minerals. This type does not contribute to the transport of chromium through sediments.
- The fourth type consists of hexavalent chromium (in the form of barium chromate) that most likely precipitated out of the oversaturated soil solution. Under the tested conditions, this type does not contribute to the overall transport of hexavalent chromium.

### 2.5.2.9 In Situ Biostimulation Test

***M. J. Truex, V. R. Vermeul, and J. S. Fruchter***

An EM-22 study of in situ biostimulation is being conducted in the 100-D Area. Biostimulation involves adding nutrients to groundwater to stimulate existing bacteria capable of reducing contaminants. In situ biostimulation is intended to provide supplemental treatment upgradient of the redox barrier by reducing the concentration of nitrate, dissolved oxygen, and chromium. The intent is to increase the longevity of the redox barrier and help diminish the chromium plume.

The treatability study is examining two commercially available approaches, one using a soluble substrate (molasses) and the other using an immiscible substrate (emulsified vegetable oil). The results summarized here describe the first year of a planned two-year treatability test.

A solution of water, molasses, ammonium chloride, and potassium bromide were injected into well 199-D5-107. (The test wells are not shown on Figure 2.5-1, but are located just downgradient of well 199-D5-40.) Total injection volume was 594,000 L. Adjacent monitoring wells were sampled during and after injection.

The following is a brief, interim summary of the field test results with respect to the field test objectives. These results will be updated to evaluate the longevity of the treatment zone.

***In recent biostimulation test, a solution of molasses was injected into the aquifer to stimulate bacterial growth and reduce hexavalent chromium.***

- Determine the effective radius of injection. An injection radius of about 15 m from the injection well for a labile substrate is obtainable. However, rapid biomass buildup near the injection well would need to be addressed for longer duration substrate injection.
- Evaluate the uniformity of substrate distribution. Uniformity of substrate injection was dependent on aquifer heterogeneities. However, the field test injection was able to distribute substrate to all of the monitoring locations, though at different concentrations. Microbial activity and maintenance of reducing conditions have been observed at all monitoring locations for at least one year.
- Induce fermentation reactions and reducing conditions and grow biomass. Process monitoring data showed that fermentation reactions and associated reducing conditions occurred at all of the monitoring locations and persisted for up to 10 months.
- Quantify the ability to obtain and maintain low chromium, oxygen, and nitrate/nitrite concentrations and determine longevity of treatment. Chromium concentrations have been maintained below 40 µg/L during the first year of monitoring. Low oxygen, nitrate, and nitrite concentrations have been maintained.

In summary, treatability test results to date have demonstrated that the soluble substrate process is an effective means for developing an in situ treatment barrier in the 100-D Area. Reduced conditions and treatment of nitrate and chromium have been maintained over a one-year period with indications that these conditions will continue. Additional monitoring of the treatability test will be conducted to quantify the longevity of treatment.

***Groundwater monitoring in the 100-HR-3-D groundwater interest area includes the following monitoring activities.***

***CERCLA and AEA Monitoring (Appendix A)***

- ***Ten wells are scheduled for quarterly to semiannual sampling for the pump-and-treat systems. The wells were sampled as planned.***
- ***Thirty-one wells are scheduled for monthly or quarterly sampling for the redox system. Seven wells were sampled less frequently than planned in FY 2008.***
- ***Forty-one wells are scheduled for monthly to biennial sampling throughout the 100-D Area. Eleven wells were sampled less frequently than planned in FY 2008.***
- ***Thirty-two wells are scheduled for quarterly to biennial sampling in the horn area between 100-D and 100-H Areas. The wells were sampled as planned.***
- ***The DOE installed four new wells in FY 2008 to investigate chromium sources in the southern 100-D Area.***
- ***The DOE installed 15 new wells and 18 new aquifer tubes to monitor contaminants in the horn.***

**Figure 2.5-1. Facilities and Groundwater Monitoring Wells in the 100-D Area.**

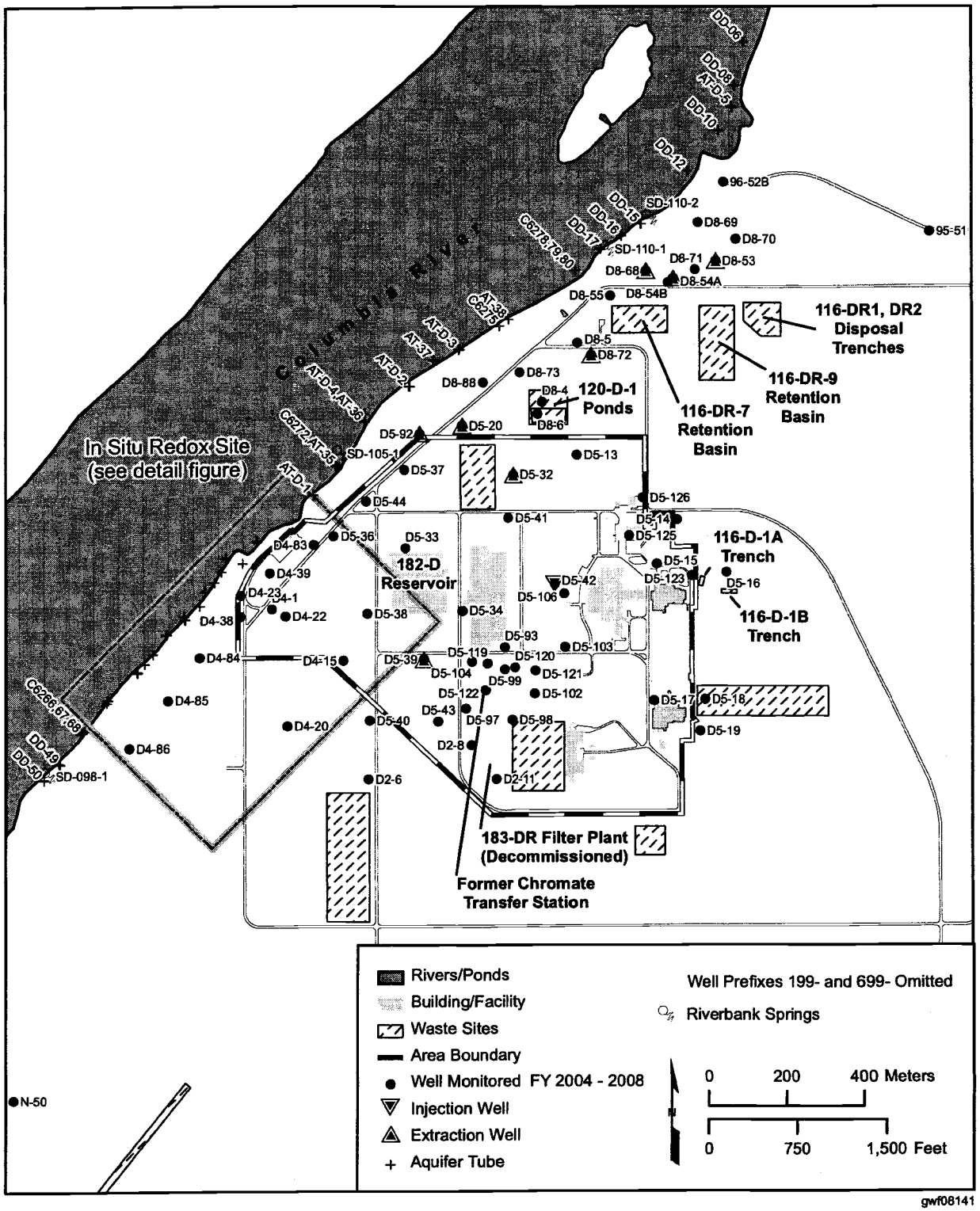


**Figure 2.5-2. Facilities and Groundwater Monitoring Wells near the Redox Site, 100-D Area.**

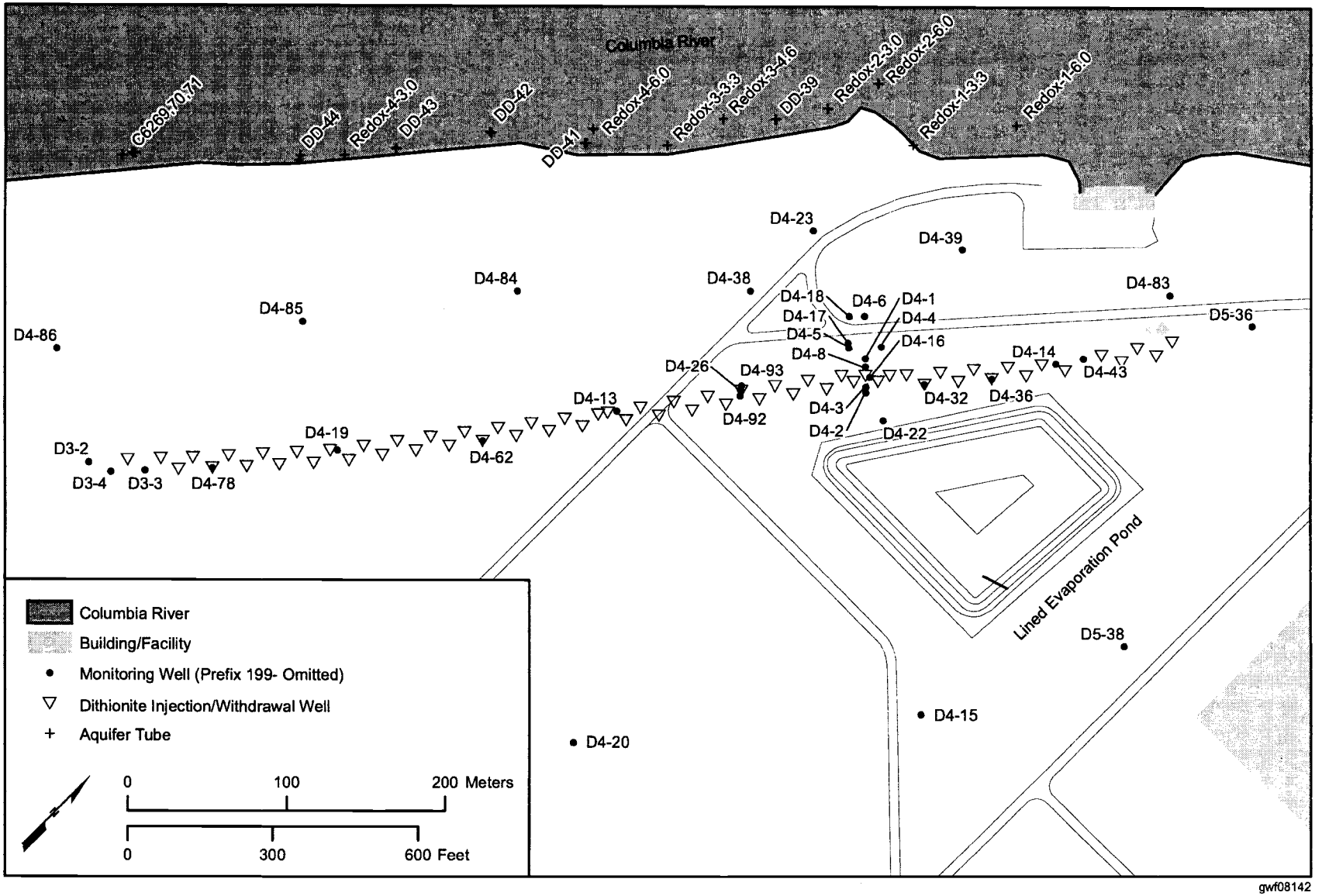


**Figure 2.5-3. 100-D Area Water-Table Map, March 2008.**

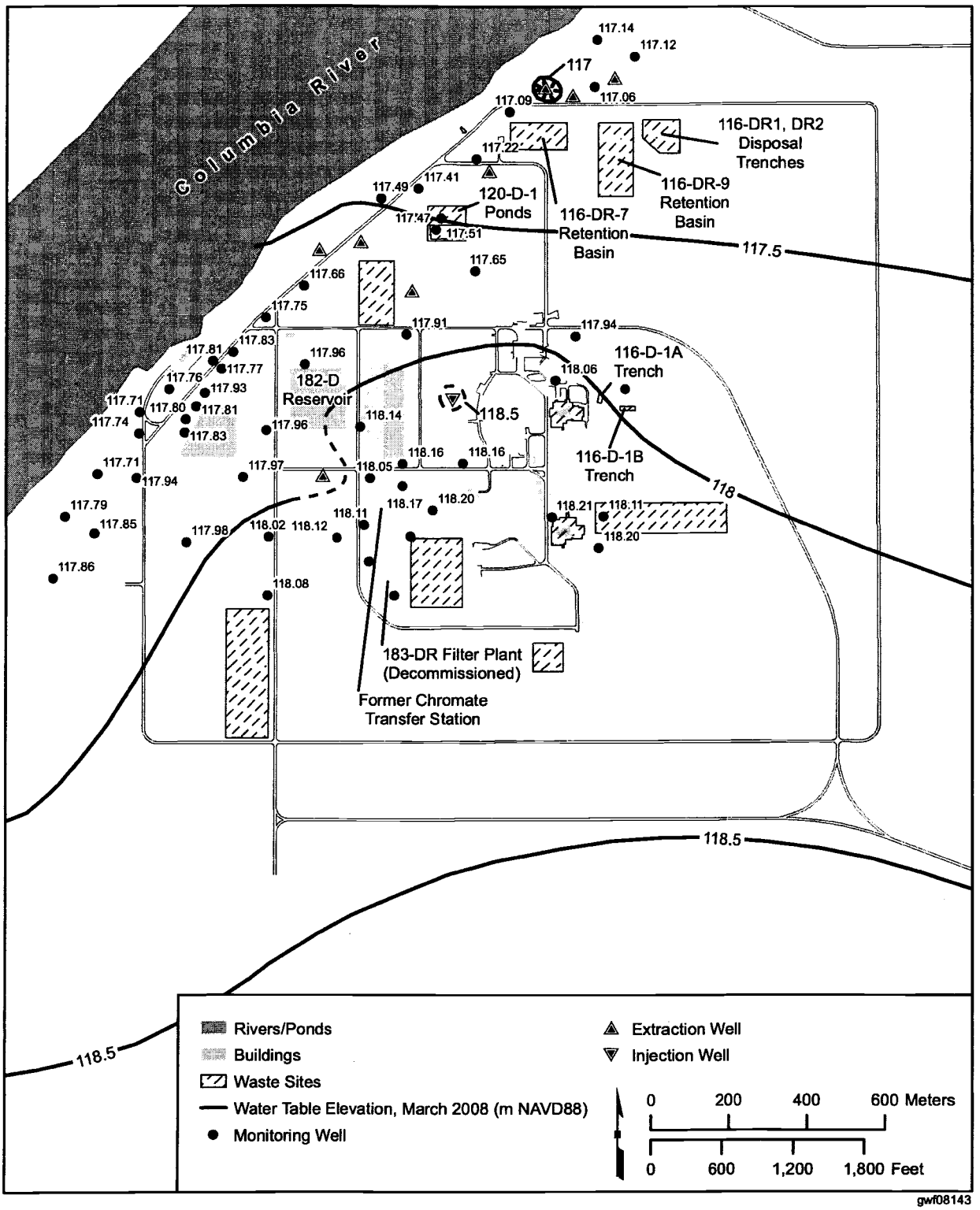


**Figure 2.5-4. Average Chromium Concentrations in the 100-D and 100-H Areas, Upper Part of Unconfined Aquifer.**

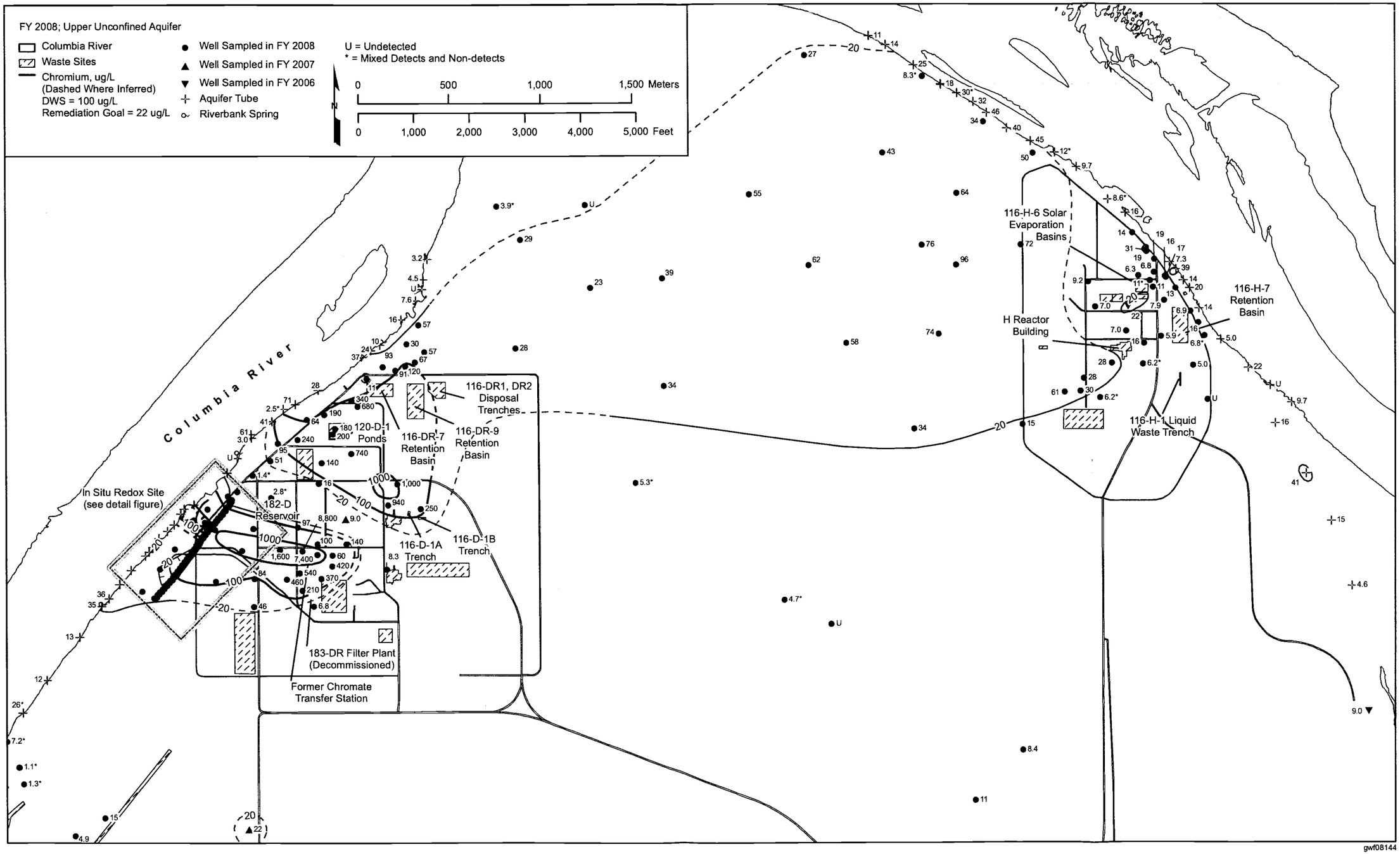


**Figure 2.5-5. Hexavalent Chromium Concentrations near Redox Site, 100-D Area, August 2008, Upper Part of Unconfined Aquifer.**

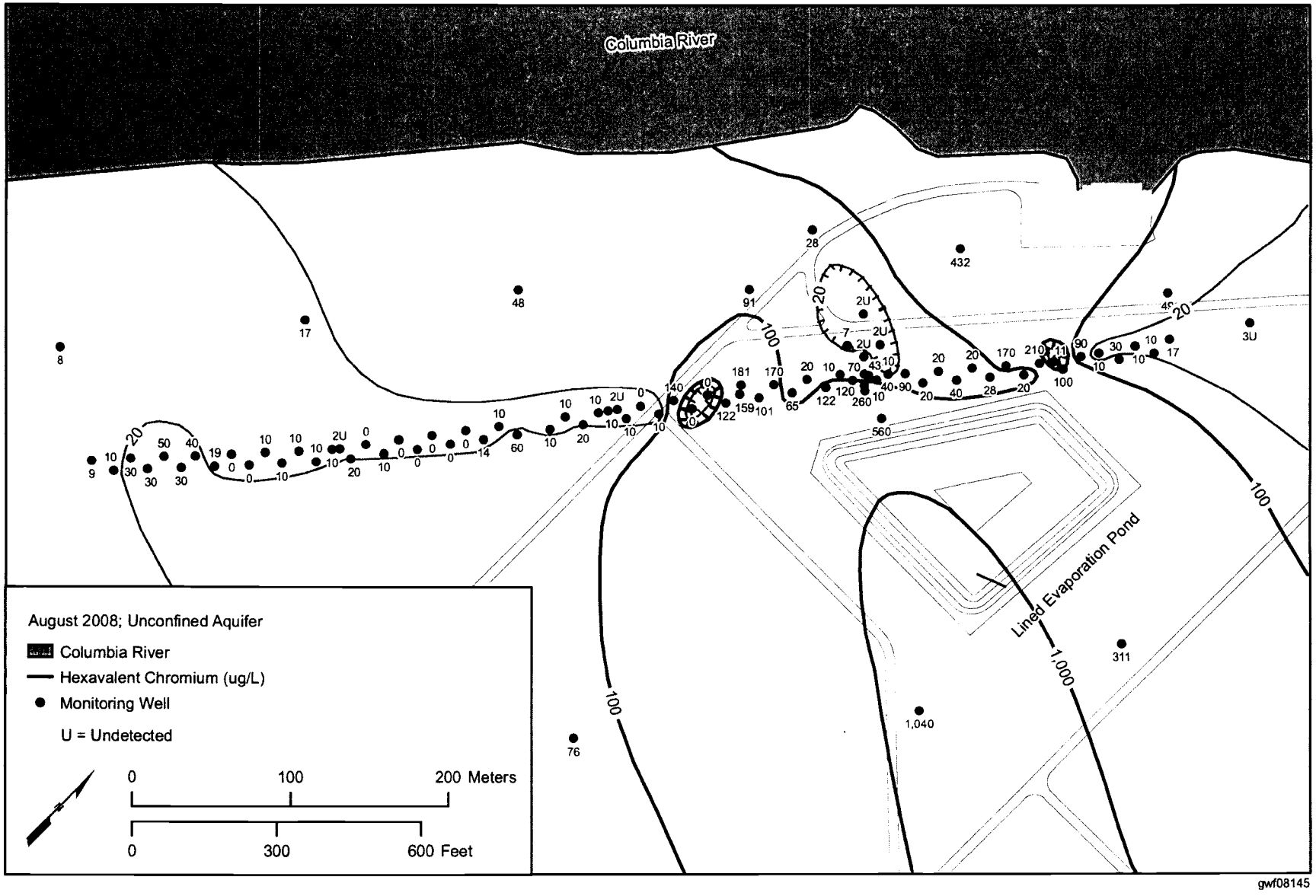
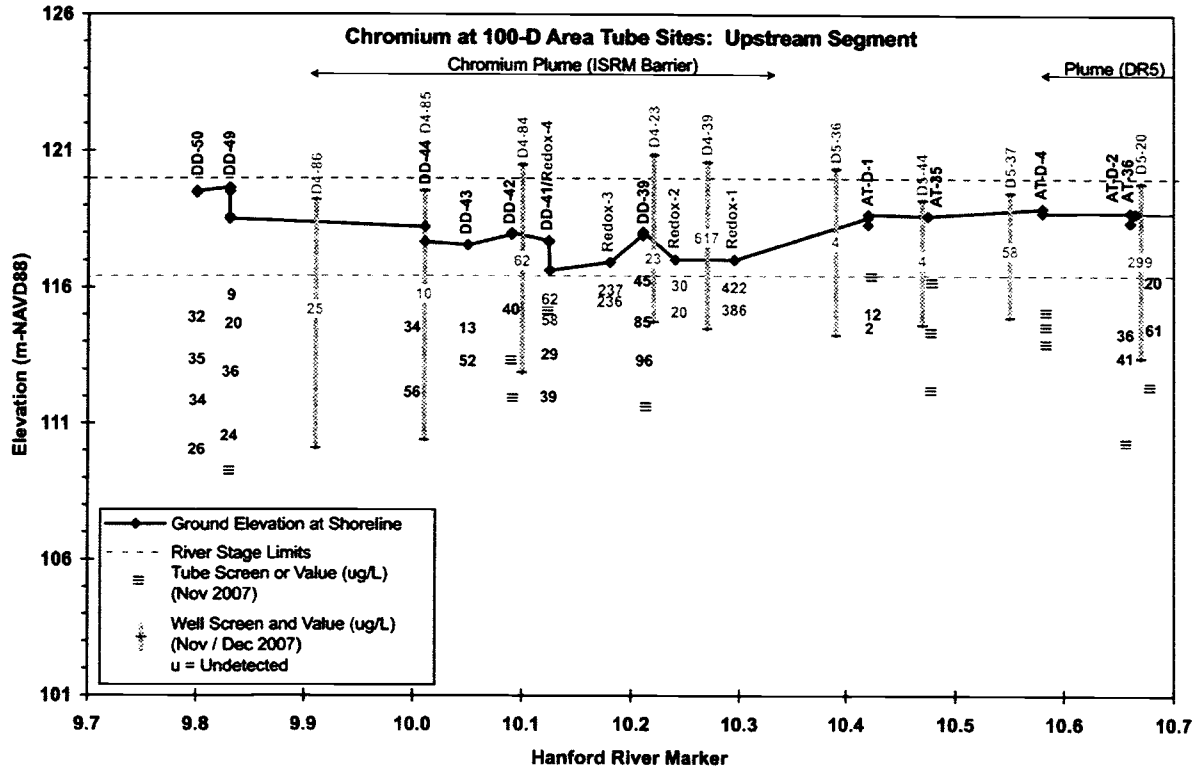


**Figure 2.5-6. Cross-Section of Chromium Concentrations and Screen Elevations in Wells and Aquifer Tubes in the 100-D Area.**



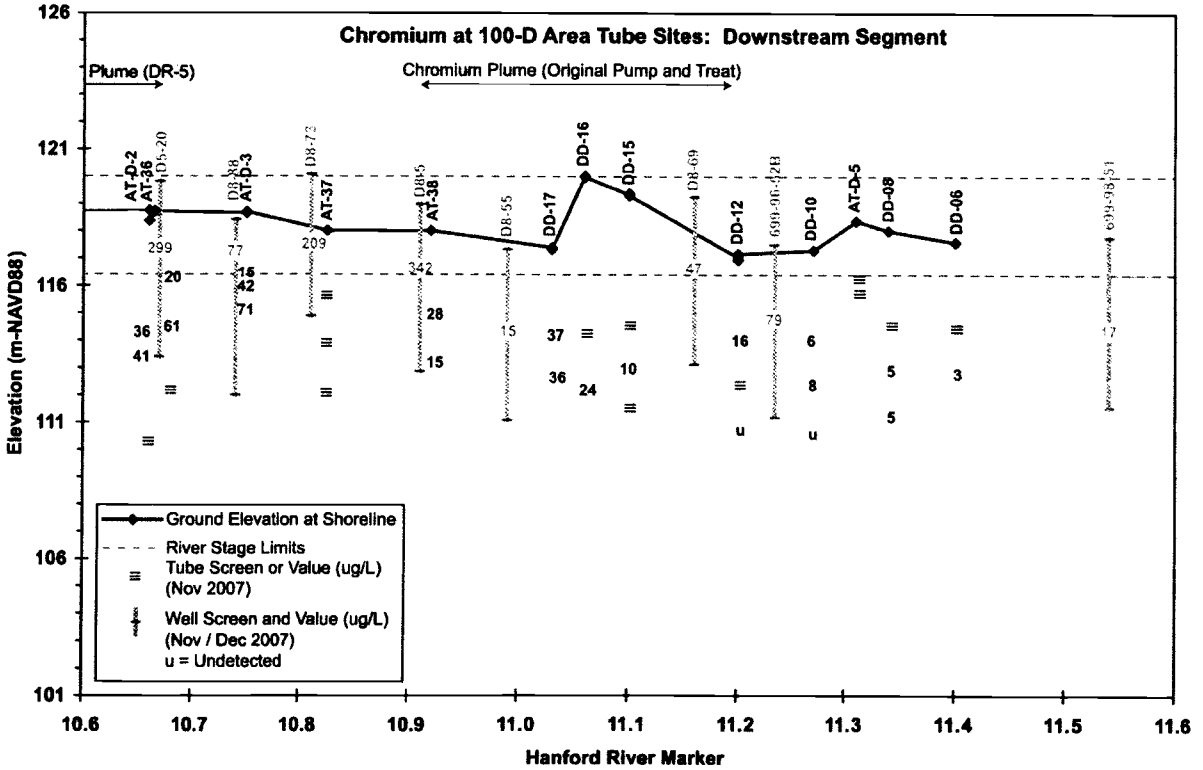




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**Figure 2.5-7. Hexavalent Chromium Concentrations at Selected Aquifer Tube Sites in 100-D Area.**

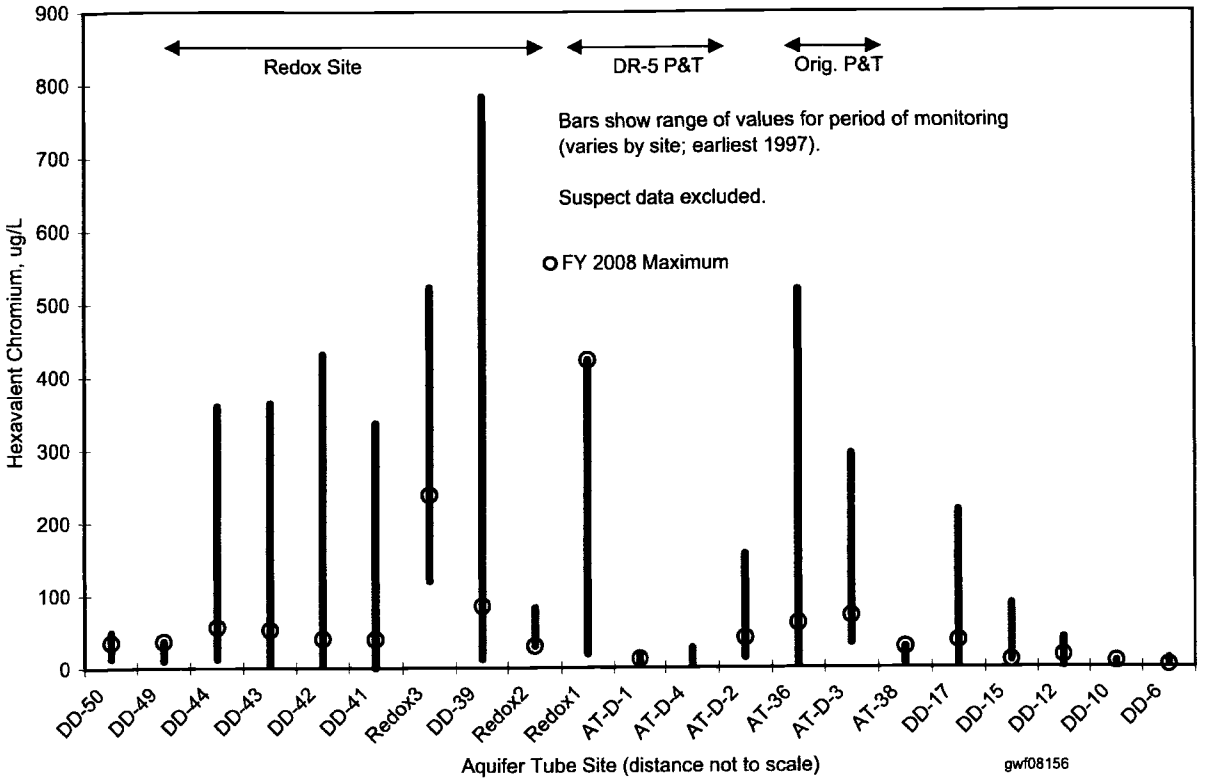
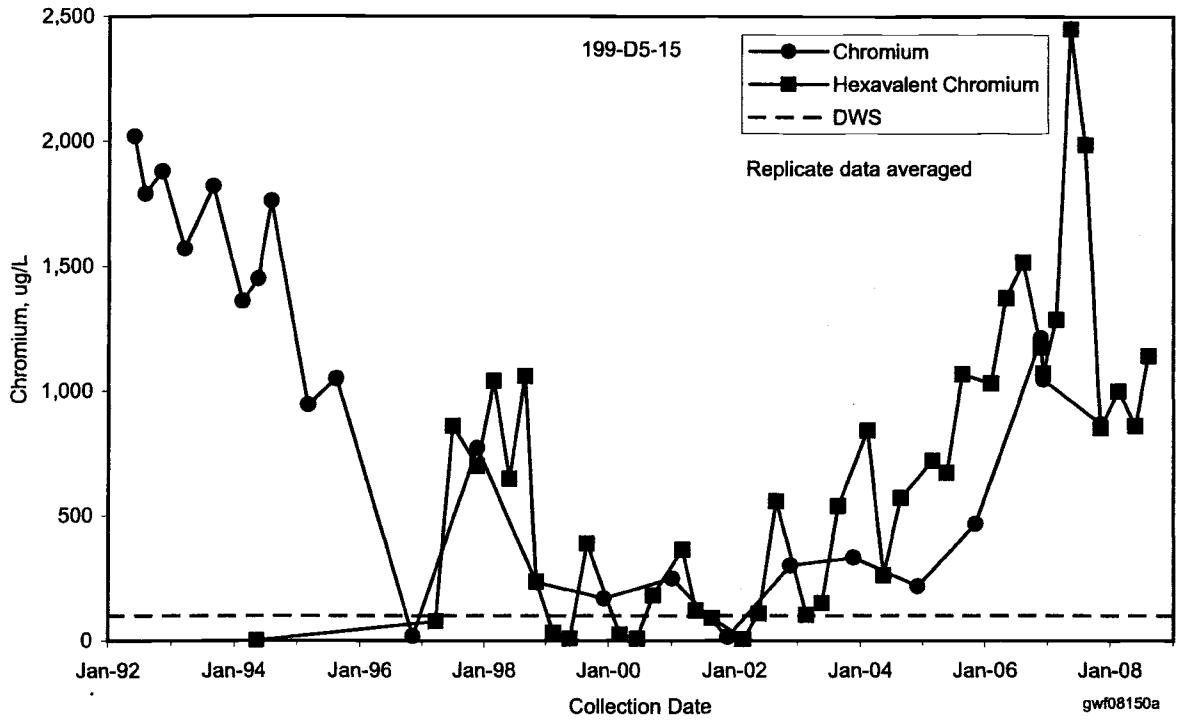


**Figure 2.5-8. Chromium Concentrations in Wells near the D Reactor.**



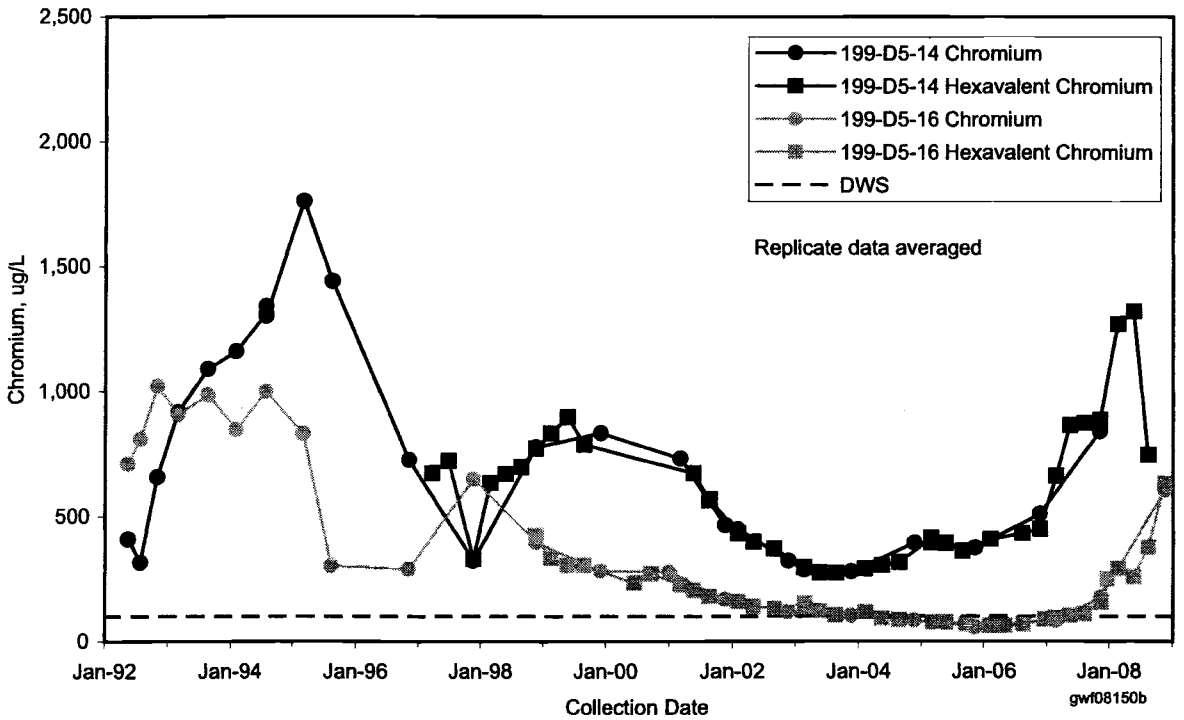



**Figure 2.5-9. Hexavalent Chromium Concentrations in Compliance Wells for the 100-HR-3 Pump-and-Treat System at 100-D Area.**

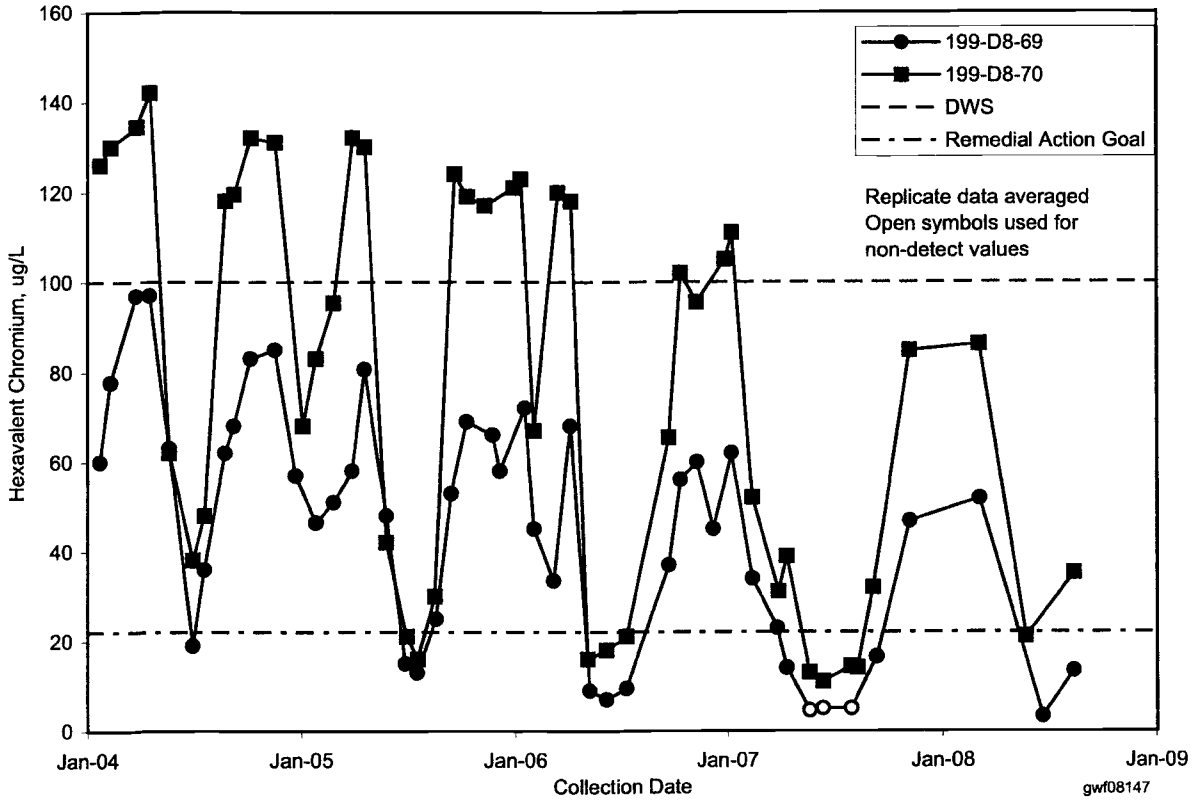



**Figure 2.5-10. Hexavalent Chromium Concentrations in Central 100-D Area Extraction Wells.**

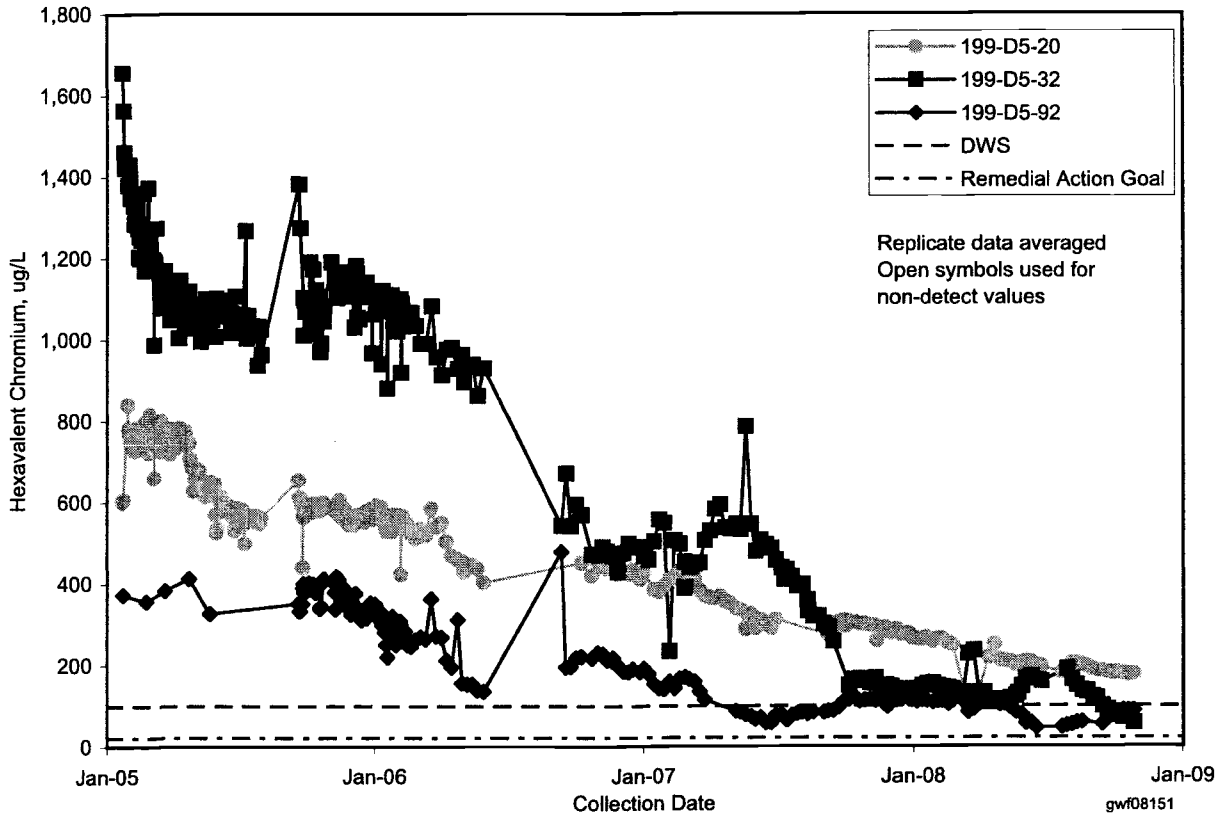


**Figure 2.5-11. Hexavalent Chromium Concentrations in Well 199-D5-41, Central 100-D Area.**

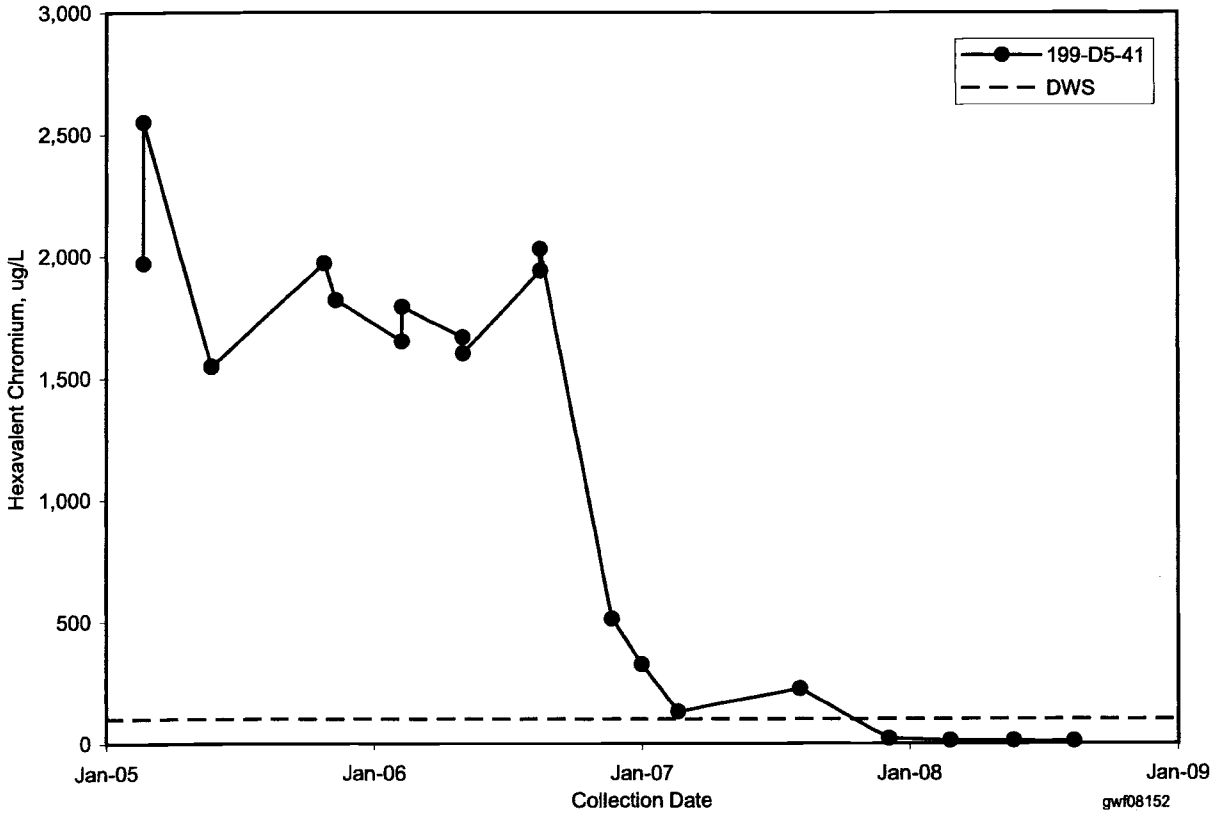



**Figure 2.5-12. Hexavalent Chromium Concentrations in South-Central 100-D Area.**

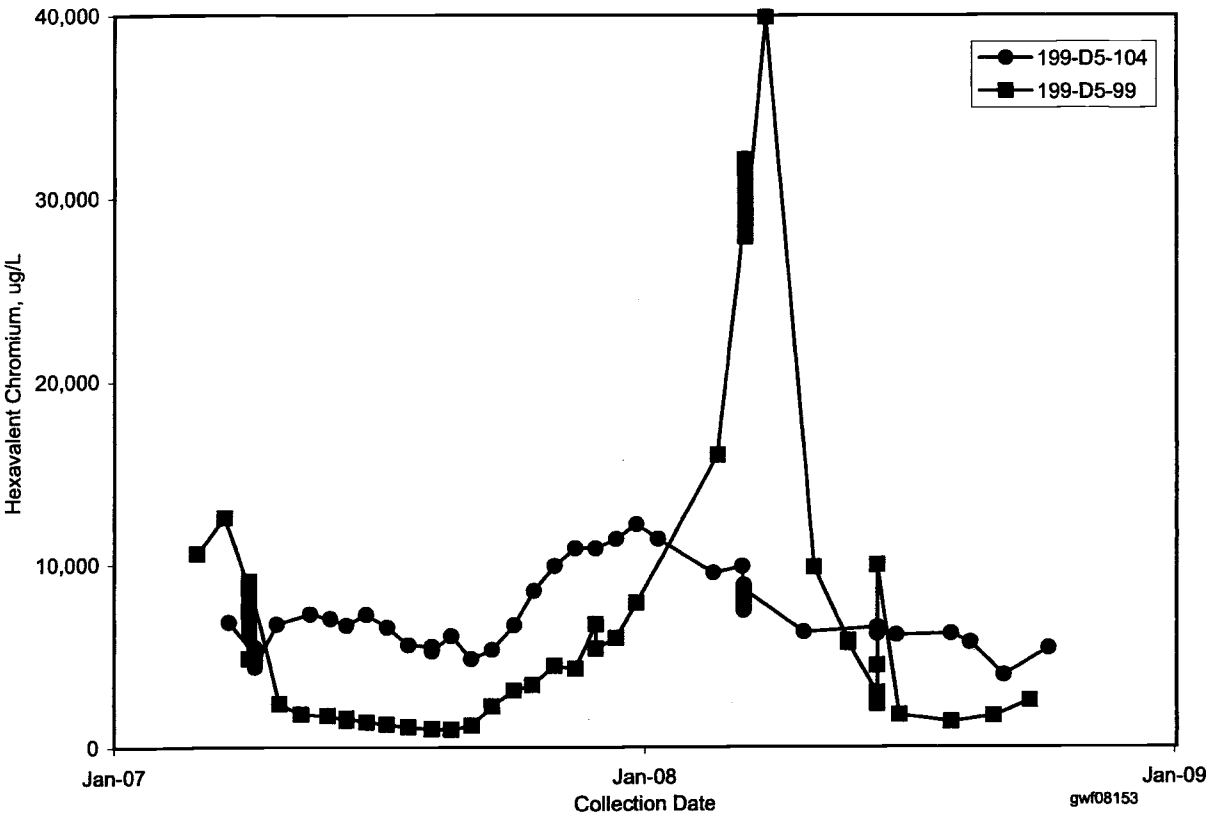
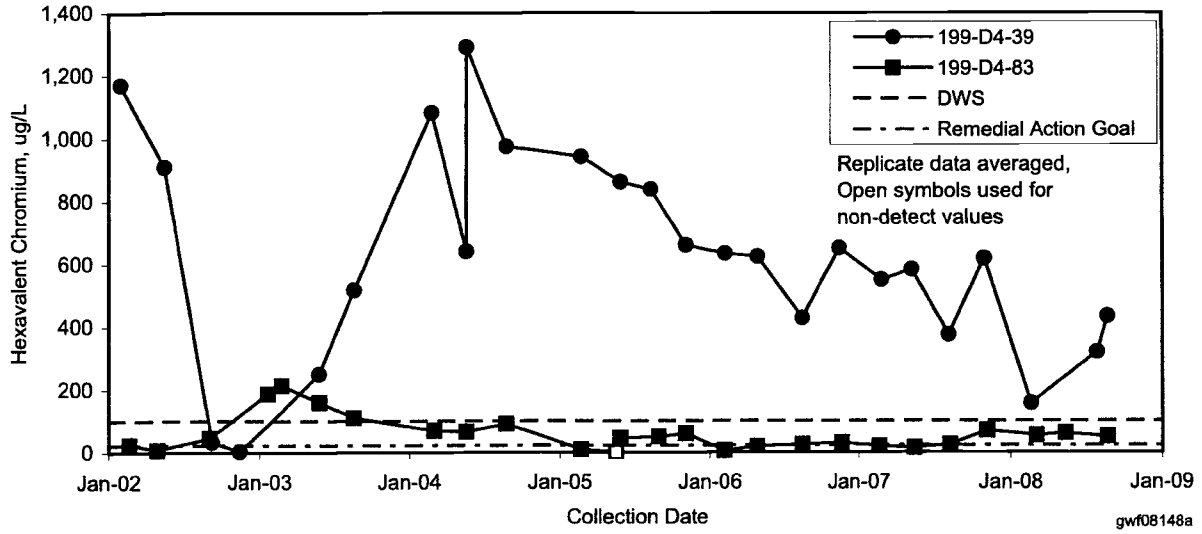
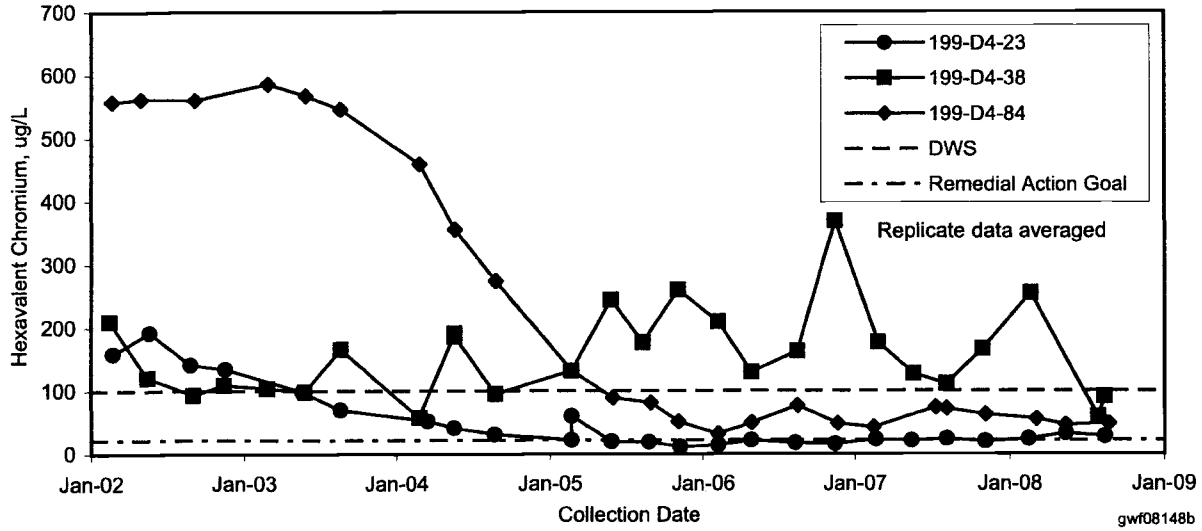


**Figure 2.5-13. Hexavalent Chromium Concentrations in Compliance Wells Downgradient of the Redox Barrier.**



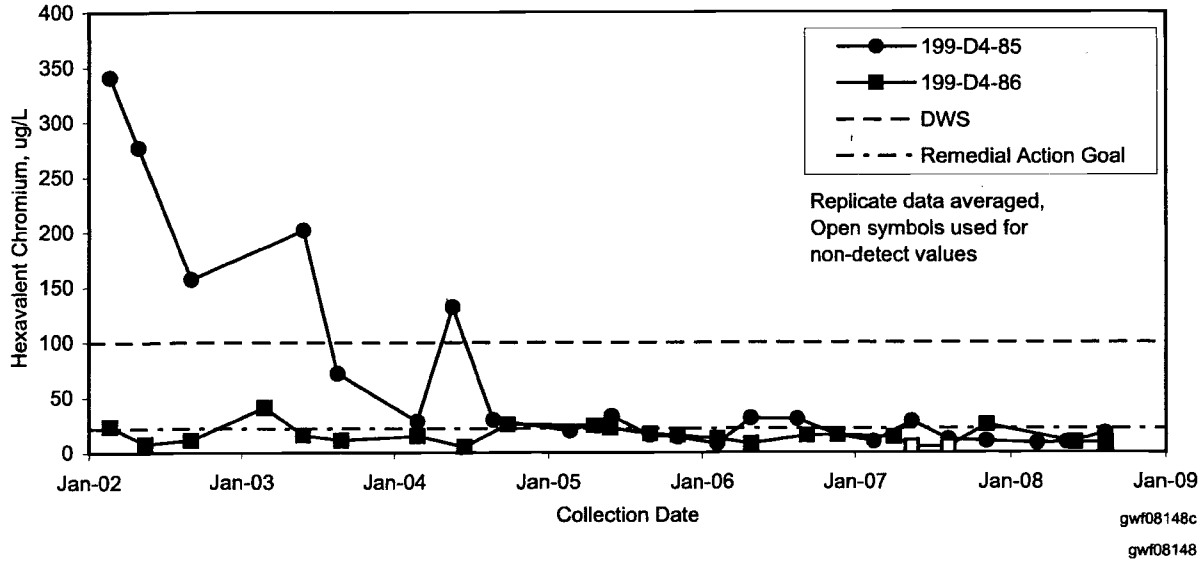




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**Figure 2.5-14. Hexavalent Chromium Concentrations in Aquifer Tubes Downgradient of the Redox Barrier.**

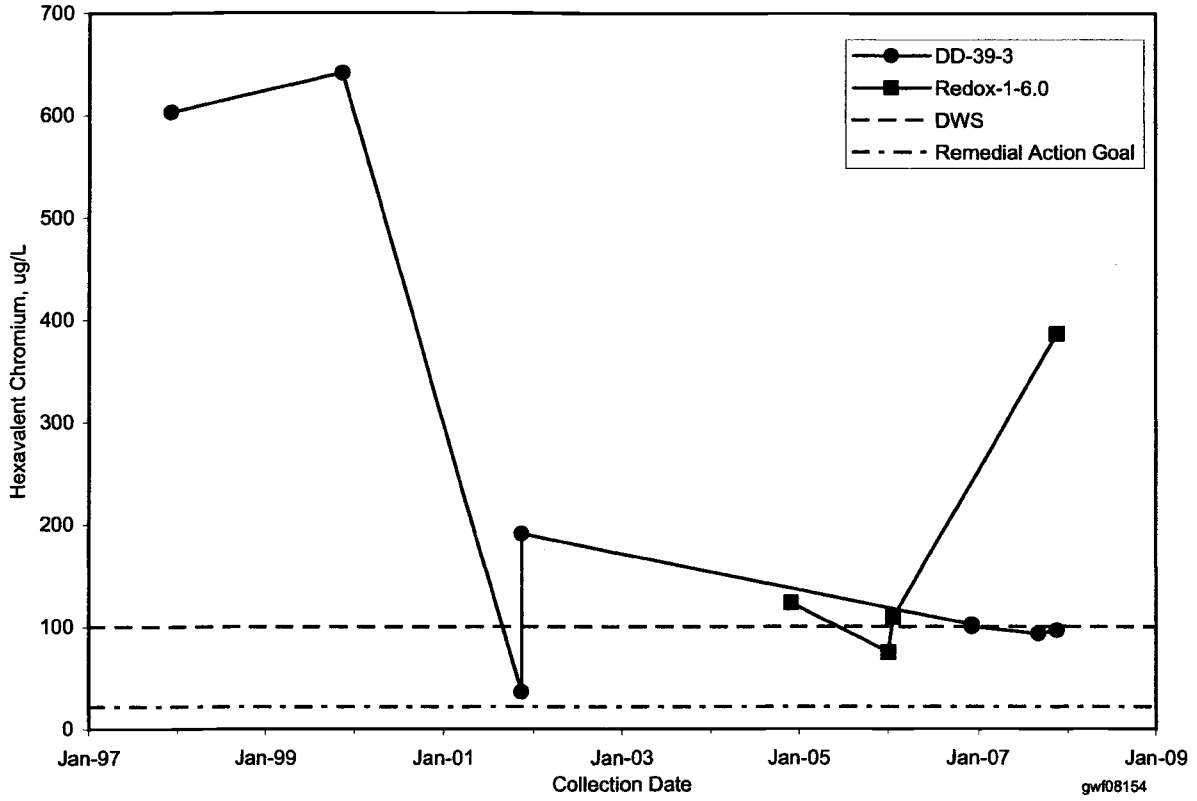



**Figure 2.5-15. Tritium Concentrations in Southern 100-D Area.**

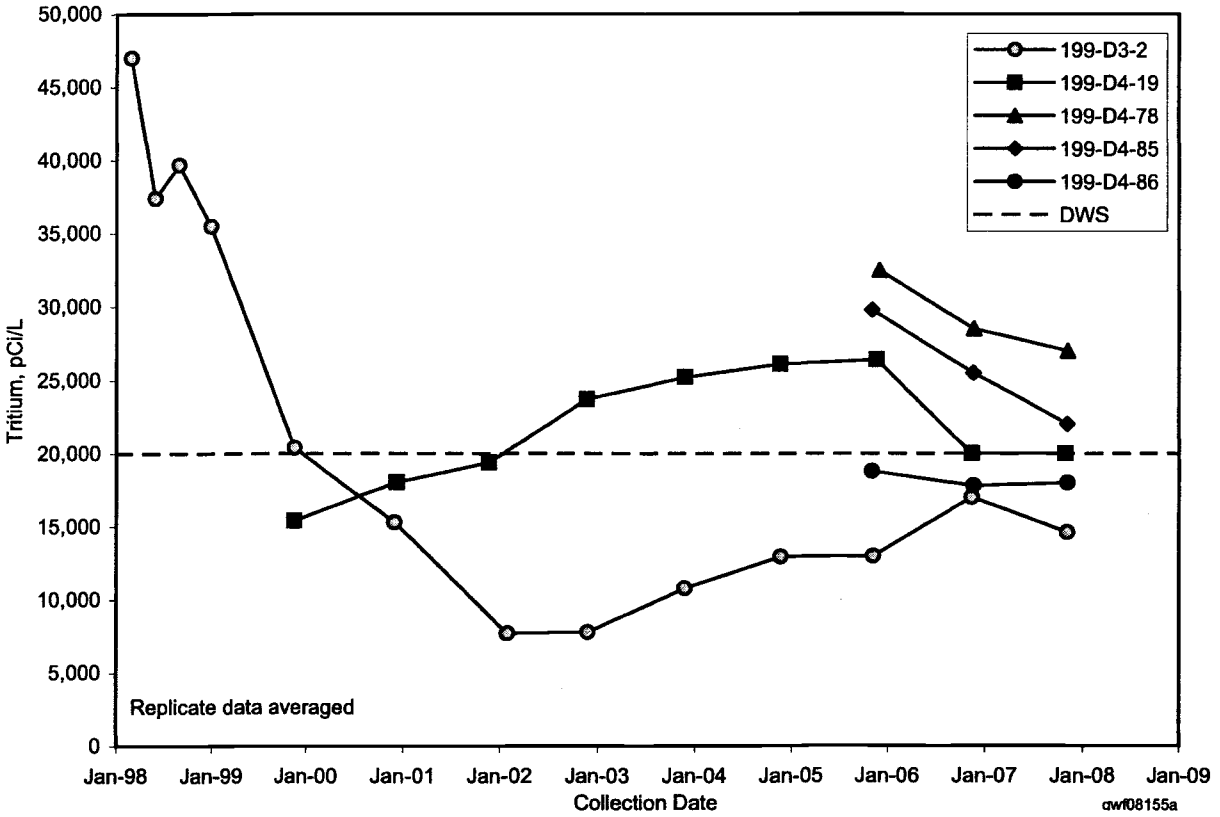


**Figure 2.5-16. Average Nitrate Concentrations in the 100-D Area, Upper Part of Unconfined Aquifer.**

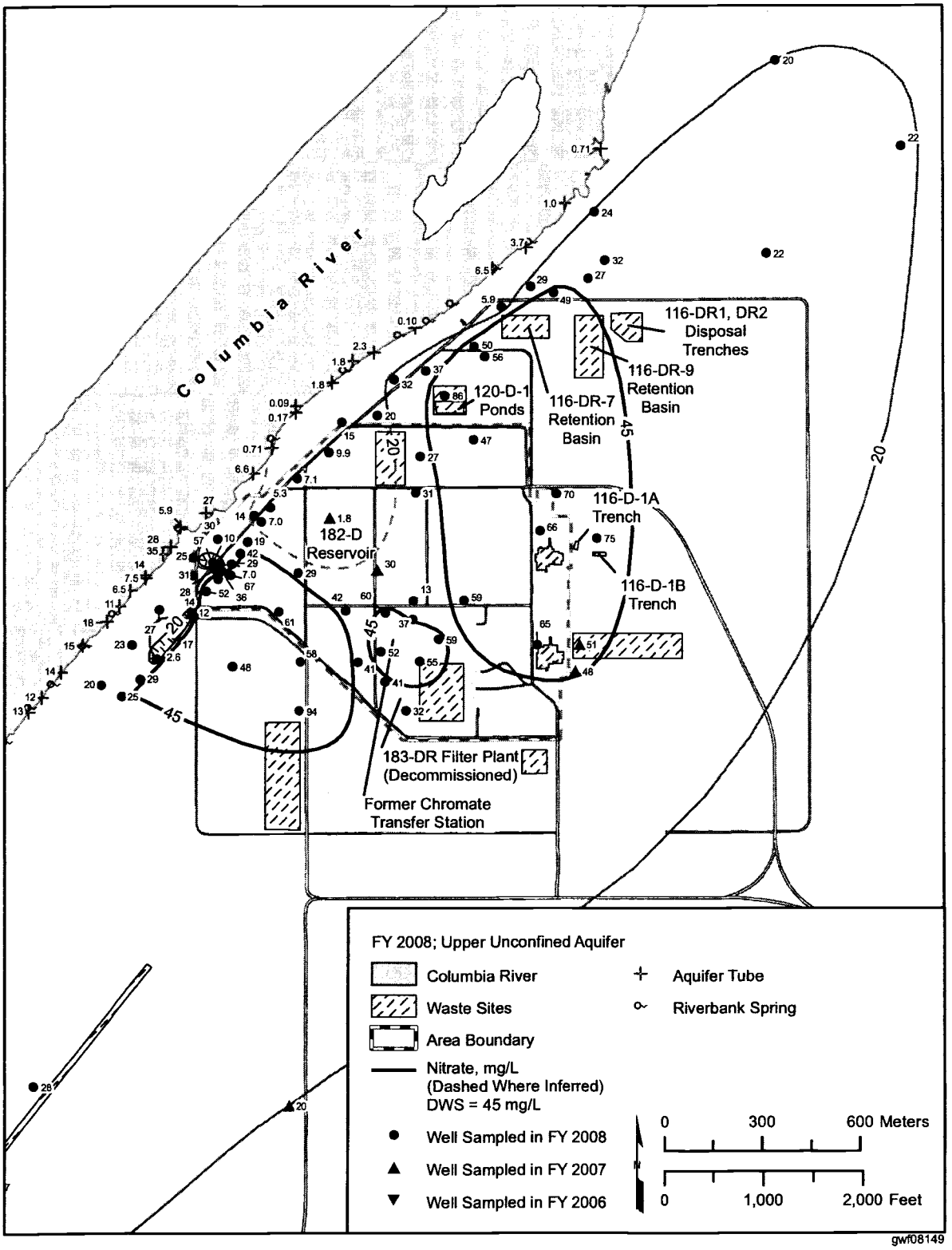
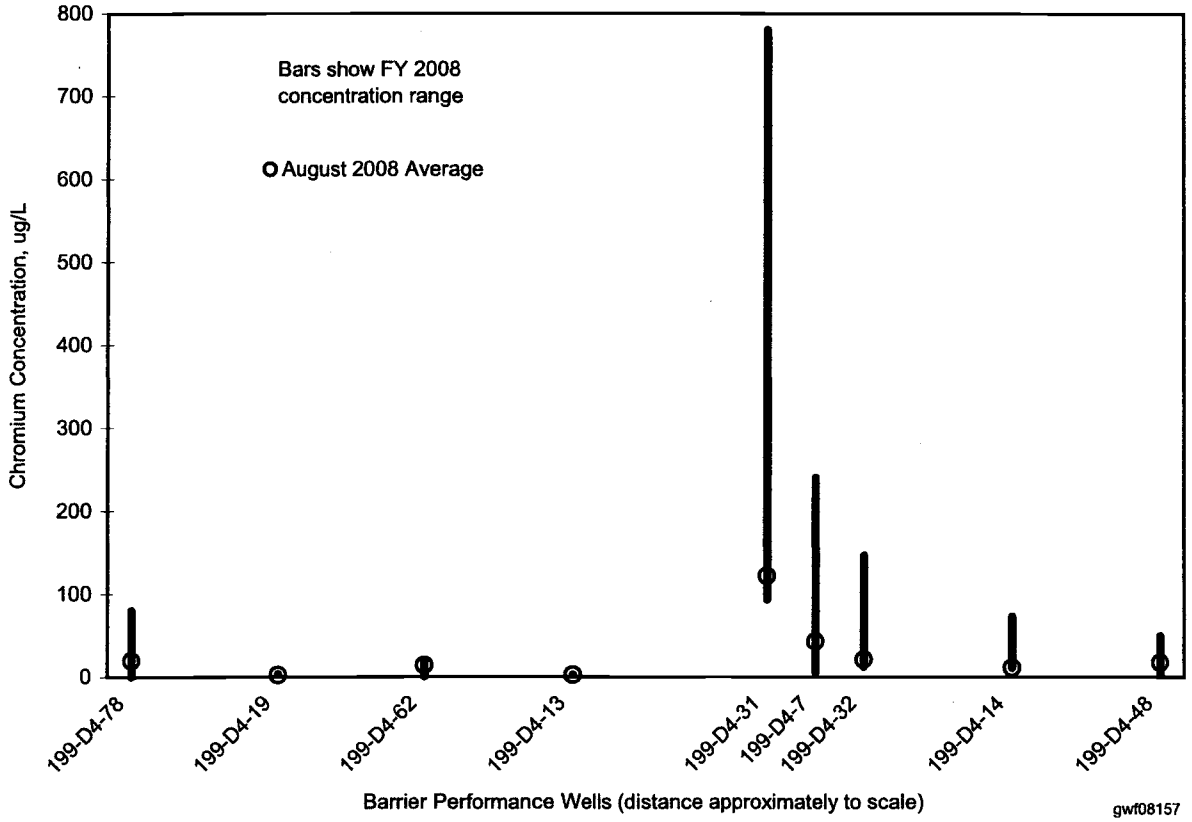


**Figure 2.5-17. Chromium Concentrations in Redox Barrier Performance Wells.**



# 2.6 100-HR-3-H Groundwater Interest Area

***M. J. Hartman***

This section describes groundwater flow and chemistry in the 100-HR-3-H groundwater interest area (including the 100-H Area located in the eastern portion of the 100-HR-3 Operable Unit). Figure 1.0-1 shows the 100-HR-3-H groundwater interest area location on the Hanford Site. Figure 2.6-1 shows facilities, wells, and shoreline monitoring sites in the 100-H Area. Hexavalent chromium is the principal contaminant of concern in 100-H Area groundwater.

***Hexavalent chromium is the principal contaminant of concern in the 100-H Area. A pump-and-treat system helps reduce the amount reaching the Columbia River.***

Groundwater flows primarily toward the east-northeast beneath the 100-H Area, discharging to the Columbia River (Figure 2.6-2). Local flow directions are influenced by groundwater extraction and injection. Since groundwater flows generally toward the northeast across the entire horn of the Hanford Site north of Gable Mountain, groundwater approaching the 100-H Area may contain contaminants that originated in the 100-D and 100-N Areas.

There is an upward hydraulic gradient between the confined and unconfined aquifers in the 100-H Area, based on data from well 199-H4-15B (unconfined aquifer) and piezometers 199-H4-15CQ (Ringold upper mud unit) and 199-H4-15CP (basalt-confined aquifer). In March 2008 the gradient between the Ringold upper mud unit and the unconfined aquifer was 0.012. The gradient between the basalt-confined and unconfined aquifers was 0.09. Well 199-H4-15CP is capped, or it would be flowing at the surface.

Some of the main concepts associated with the 100-HR-3-H groundwater interest area include the following.

- Principal sources of groundwater contamination included liquid waste sites (trenches, cribs, and basins). The waste sites have been remediated (shallow contaminated sediment has been excavated) and backfilled.
- Hexavalent chromium is the principal contaminant of concern in groundwater. The portion of the plume within the 100-H Area has shrunk and concentrations have declined.
- A pump-and-treat system removed ~2.3 kg of hexavalent chromium from the aquifer in fiscal year (FY) 2008, and ~51 kg since 1997. Concentrations in groundwater are mostly below the 22 μg/L remedial action goal.
- Strontium-90 and nitrate contamination also is present in groundwater.
- One *Resource Conservation and Recovery Act of 1976* (RCRA) unit is located in the 100-H Area. It is monitored under an alternative program in conjunction with the interim remedial action.
- Most of the wells in the 100-H Area are screened at the top of the unconfined aquifer, which is 2 to 6 m thick. Three wells completed in the Ringold upper mud unit have higher concentrations of chromium than shallow wells. The U.S. Department of Energy (DOE) will characterize this contamination in coming years.

The 100-H Area groundwater is monitored for the objectives of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), the *Atomic Energy Act of 1954* (AEA), and the 116-H-6 (183-H) Solar Evaporation Basins (a RCRA unit). Section 2.6.1 describes contaminant plumes and concentrations;

Section 2.6.2 summarizes operable unit activities; and Section 2.6.3 discusses groundwater monitoring of the 116-H-6 Solar Evaporation Basins.

## 2.6.1 Groundwater Contaminants

Wells in the 100-H Area are sampled for hexavalent chromium and co-contaminants identified under CERCLA: strontium-90, technetium-99, uranium, tritium, and nitrate (EPA/ROD/R10-96/134, p. 42). This section describes the distribution and trends of those groundwater contaminants beneath the 100-H Area.

***Plume areas (square kilometers) in the 100-HR-3-H groundwater interest area:***

***Chromium,* 20 µg/L — 4.0***

***Nitrate, 45 mg/L — 0.03***

***Strontium-90, 8 pCi/L — 0.15***

****Includes chromium plume west to boundary with 100-HR-3-D groundwater interest area.***

### 2.6.1.1 Chromium

Hexavalent chromium is the contaminant of concern for the 100-HR-3 Operable Unit interim action (EPA/ROD/R10-96/134), which includes the 100-H Area. The interim action record of decision requires remediation using a pump-and-treat system (Section 2.6.2).

The portion of the chromium plume in the 100-H Area where concentrations exceed the remedial action goal of 22 µg/L has shrunk substantially in recent years (Figure 2.5-4). Concentrations in shallow wells have been below the 100 µg/L drinking water standard since 2001. Well 199-H3-5 had the maximum concentration (72 µg/L in February 2008) in a shallow well for FY 2008. This is one of three former injection wells located in the southern 100-H Area where chromium concentrations have increased in recent years (Figure 2.6-3). Injection of treated water into these wells ceased in 2005. The source of chromium in this area is believed to be the 600 Area plume that originated in the 100-D Area.

Prior to FY 2008, the highest 100-H Area chromium concentrations were in well 199-H4-3, which is downgradient of the 116-H-6 Solar Evaporation Basins. In FY 2008, chromium concentrations in well 199-H4-3 ranged from less than 10 µg/L in November and December 2007 to 35 µg/L in August 2008 (Figure 2.6-4). Chromium peaks during the summers of 2006, 2007, and 2008 followed periods of elevated river stage. Co-contaminants nitrate, technetium-99, and uranium showed similar trends in 2006 and 2007. These constituents were not analyzed in samples from summer 2008. The concentration increases could be caused by movement of contamination from the lower vadose zone into groundwater, or possibly changing directions of groundwater flow because of seasonal variations or pump-and-treat effects.

***Chromium concentrations were all below the drinking water standard in the upper aquifer of the 100-H Area, and most averaged less than the 22 µg/L remedial action goal in FY 2008.***

Well 199-H4-3 has been an extraction well for the pump-and-treat system since August 2005. Chromium concentrations in November 2007 in the other five extraction wells are plotted in Figure 2.6-5. Most of the FY 2008 results were below the 22 µg/L remedial action goal.

Several wells upgradient of the 100-H Area continued to have chromium concentrations near or above the drinking water standard. The highest concentration for FY 2008 was 117 µg/L (hexavalent chromium) in well 699-97-43B in October 2007. This contamination probably originated in the 100-D Area when a water-table mound was present (WHC-SD-EN-TI-023, *Hydrogeologic Information Summary for the Northern Hanford Site*). This plume is the subject of an ongoing investigation of the horn (Section 2.5.2.4). An upcoming report will include a hydrogeological summary of the area.

Figure 2.6-6 shows chromium concentrations in November 2007 in aquifer tubes and near-river wells in two cross sections parallel to the Columbia River. The top panel includes recently installed aquifer tubes on the east side of the horn. The highest concentrations (~60 µg/L) were observed in two shallow tubes near the south end of the cross section. Some of these tubes were sampled quarterly in FY 2008. The highest concentration in May 2008 was 73.4 µg/L in a deep tube, C5674 (45.9 µg/L in the shallow tube). The bottom panel of Figure 2.6-6 shows chromium concentrations along the 100-H Area and downstream. The highest concentration was 41 µg/L in tube AT-51-D, downstream of 100-H Area.

Three wells monitoring a water-bearing layer within the Ringold upper mud unit continued to have elevated chromium concentrations (Figure 2.6-7). These wells (199-H3-2C, 199-H4-12C, and 199-H4-15CS) are screened at elevations ranging from 94 to 104 m. Adjacent water-table wells are screened from 112 to 117 m. Well 199-H3-2C is located on the western side of 100-H Area, upgradient of waste sites. Chromium concentrations in this well have increased over the last several years, reaching ~50 µg/L in FY 2007 and FY 2008. Adjacent well 199-H3-2A, completed at the water table, has much lower chromium concentrations (less than 10 µg/L). Well 199-H4-12C is located near the river, downgradient of the 116-H-6 Solar Evaporation Basins and adjacent to extraction well 199-H4-12A. Well 199-H4-12C has declining chromium concentrations. Piezometer 199-H4-15CS also is adjacent to an extraction well. Chromium concentrations in the piezometer are steady at levels just above the drinking water standard. Three deeper piezometers in well 199-H4-15C showed lower chromium levels, with a maximum concentration of 50 µg/L in piezometer 199-H4-15CR. Concentrations of other contaminants that would indicate the influence of the 116-H-6 Solar Evaporation Basins (e.g., nitrate, technetium-99, and uranium) are low in the deeper wells. The source of this deeper chromium is unknown. The deep chromium contamination is being investigated in response to a five-year review action item (Section 2.6.2.1).

***The Ringold upper mud unit does not appear to be contaminated across the horn.***

The Ringold upper mud unit does not appear to be contaminated across the horn. In FY 2007 and FY 2008, the DOE installed three wells in the horn to monitor the Ringold upper mud unit: 699-97-43C, 699-97-45B, and 699-97-48C. Routine samples from the wells had concentrations less than 20 µg/L. During development (extended pumping) of well 699-97-48C, chromium concentrations rose to ~40 µg/L. Routine samples in the subsequent months had levels less than 20 µg/L. The chromium in the upper mud unit at this well may have been introduced during drilling, or may be a remnant of local contamination introduced by a nearby well that was formerly screened across a long interval.

### 2.6.1.2 Strontium-90

Strontium-90 concentrations continued to exceed the drinking water standard (8 pCi/L) in two wells. Both of these wells are located in southeastern 100-H Area near the former retention basin and disposal trenches. The highest concentration in FY 2008 was 24.8 pCi/L in well 199-H4-63, confirming a declining trend. The strontium-90 contamination causes gross beta concentrations to exceed the 50 pCi/L drinking water standard in the region of the plume. The highest gross beta concentration in FY 2008 was 57.2 pCi/L in well 199-H4-13, equivalent to ~28 pCi/L strontium-90 (samples from well 199-H4-13 were not analyzed for strontium-90).

Six aquifer tubes were sampled for strontium-90 in FY 2008: AT-47-D and -M, AT-H-3-D and –S, and new tubes C6296 and C6297. The highest concentration was 11.6 pCi/L in AT-47-M, which is near well 199-H4-63.

### 2.6.1.3 Technetium-99 and Uranium

Although detected during FY 2008 in groundwater downgradient of the former 116-H-6 Solar Evaporation Basins, technetium-99 and uranium concentrations did not exceed the drinking water standards (900 pCi/L and 30 µg/L respectively). The highest technetium-99 and uranium concentrations were in well 199-H4-3, at 31 pCi/L and 8.4 µg/L, respectively. Concentrations increased in this well during summer 2006 and 2007, along with chromium. Technetium-99 and uranium were not analyzed during summer 2008.

### 2.6.1.4 Tritium

Tritium concentrations do not exceed 2,000 pCi/L in most 100-H Area wells. The highest concentration in the 100-H Area for FY 2008 was 4,400 pCi/L in well 199-H4-49 (in the southern 100-H Area). Wells in the 600 Area upgradient of the 100-H Area have tritium concentrations greater than 2,000 pCi/L, with a maximum of 5,500 pCi/L in well 699-97-43B.

### 2.6.1.5 Nitrate

Nitrate concentrations exceeded the drinking water standard (45 mg/L) in some 100-H Area monitoring wells; however, concentrations were below the standard in FY 2008. The highest concentration in a monitoring well was 44.3 mg/L (well 199-H6-1 in the southern 100-H Area). A sample from one aquifer tube downstream from the 100-H Area, AT-51-M, had a concentration of 45.6 mg/L.

Well 199-H4-3 has had nitrate concentrations above the drinking water standard in the past. In FY 2008, the highest concentration was 35.5 µg/L in February. Nitrate peaks during the summers of 2006 and 2008 coincided with peaks in chromium, technetium-99, and uranium (Sections 2.6.1.1 and 2.6.1.3). The well was not sampled during summer 2008.

## 2.6.2 Operable Unit Activities

***The remedial action objectives for the 100-HR-3 Operable Unit (EPA/ROD/R10-96/134) are as follows.***

- ***Protect aquatic receptors in the river bottom from contaminants in groundwater entering the Columbia River.***
- ***Protect human health by preventing exposure to contaminants in the groundwater.***
- ***Provide information that will lead to the final remedy.***

***The contaminant of concern is hexavalent chromium. The record of decision specifies a cleanup goal of 22 µg/L at compliance wells.***

This section summarizes activities associated with groundwater in the eastern portion of the 100-HR-3 Operable Unit. Eleven new monitoring wells were installed in this region in FY 2008 as part of the horn chromium investigation (Section 2.5.2.4).

### 2.6.2.1 Status of Five-Year Review Action Item

The second CERCLA five-year review was published in November 2006 (DOE/RL-2006-20). The review identified one action[1] pertaining to the

1 Another issue pertained to chromium in the "horn" between 100-D and 100-H Areas. It is discussed in Section 2.5.

100-H Area: Action 12-1, perform additional characterization of the aquifer below the initial aquitard (September 2009).

Section 2.6.1.1 presents monitoring results. Additional work will be performed under the systematic planning process and remedial process optimization for the 100-HR-3 Operable Unit.

### 2.6.2.2 Pump-and-Treat System

A pump-and-treat system operates in the 100-H Area as part of a CERCLA interim action for the 100-HR-3 Operable Unit (EPA/ROD/R10-96/134). DOE/RL-96-90,describes interim remedial action monitoring. Long-term monitoring requirements in the 100-H Area were derived from Change Control Form 107. Figure 2.6-1 displays locations of extraction and injection wells, and Appendix A lists sampling frequencies and constituents. For interim action monitoring, one monthly sample was missed in two wells (199-H4-5 and 199-H4-63) because of conflicts scheduling field staff. For long-term monitoring, all wells were sampled as planned.

***During FY 2008, the pump-and-treat system extracted ~142.9 million liters of groundwater from the 100-H Area, removing ~2.3 kg of hexavalent chromium.***

The 100-H Pump-And-Treat System is reducing overall contamination in the operable unit by removing contaminant mass. During FY 2008, the pump-and-treat system extracted ~142.9 million liters of groundwater from the 100-H Area, removing ~2.3 kg of hexavalent chromium.

The pump-and-treat system has removed ~51 kg of hexavalent chromium from the 100-H Area groundwater since July 1997. This represents more than the ~42 kg of chromium that was estimated to be in the plume in 1992 (WHC-SA-1674-VA, *Characterization of a Chromium Plume in Groundwater along the Columbia River Shoreline, Hanford Site, Washington*). The estimate did not include chromium from upgradient sources (100-D Area) nor the vadose zone.

Chromium concentrations in 100-H Area groundwater have declined, and the plume in the uppermost aquifer has shrunk. There were no changes made to the pump-and-treat network in the 100-H Area during FY 2008.

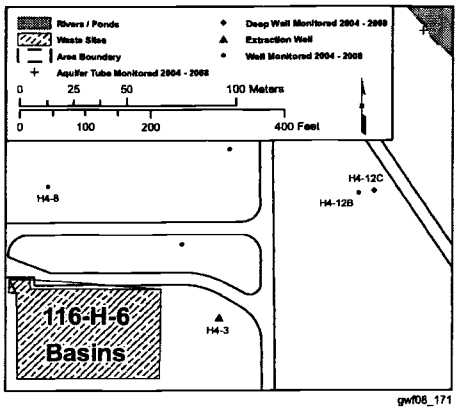
Hexavalent chromium concentrations stabilized at levels below the remedial action goal in compliance well[2] 199-H4-5. Concentrations[3] ranged from 2 to 16 µg/L in FY 2008. Most of the FY 2008 chromium concentrations[3] for former compliance wells 199-H4-4, 199-H4-63, and 199-H4-64 (now extraction wells) were below the remedial action goal (Figure 2.6-5).

Results of performance monitoring are incorporated with the discussion of general contamination in Section 2.6.1. Results of operational monitoring and additional details about the pump-and-treat system for calendar year 2007 can be found in DOE/RL-2008-05. Results for FY 2008 will be published in an upcoming annual report on the 100-HR-3, 100-KR-4, and 100-NR-2 Pump-and-Treat Systems.

2 Certain monitoring wells are designated as "compliance wells" in the interim action record of decision. Chromium concentrations in samples from these wells are compared to the remediation goal (22 µg/L) to determine if the remedial action is effective.

3 Hexavalent chromium and filtered, total chromium

## 2.6.3 Facility Monitoring — 116-H-6 (183-H) Solar Evaporation Basins




The 116-H-6 Solar Evaporation Basins are the only RCRA site in the 100-H Area. The unit was incorporated into the Hanford Facility RCRA Permit (WA7890008967) as the 183-H Solar Evaporation Basins. The site is monitored during the postclosure period under corrective action monitoring requirements of WAC 173-303-645(11)(g). The monitoring network consists of wells 199-H4-3, 199-H4-8, 199-H4-12A, and 199-H4-12C. Lists of wells and constituents monitored and a well location map are included in Appendix B.

The four wells in the RCRA network were sampled as scheduled in FY 2008 for the constituents of interest listed in the groundwater-monitoring plan (PNNL-11573, *Groundwater Monitoring Plan for the 183-H Solar Evaporation Basins*). The constituents of interest (except fluoride) were discussed in Section 2.6.1. Fluoride concentrations remained low (less than 300 µg/L) in groundwater downgradient of the 116-H-6 Solar Evaporation Basins. Two reports present groundwater monitoring results for July to December 2007 and January to June 2008 (SGW-37294 and SGW-39299, respectively).

While the 100-HR-3 Pump-And-Treat System is operating, RCRA monitoring consists of annual sampling of four wells for chromium, fluoride, nitrate, technetium-99, and uranium. Although not regulated under RCRA, technetium-99 and uranium were included in the monitoring plan for completeness and were incorporated by reference in the Hanford Facility RCRA Permit.

***Groundwater monitoring in the 100-HR-3-H groundwater interest area includes the following monitoring activities.***

***CERCLA and AEA Monitoring (Appendix A)***

- ***Twenty-seven wells are scheduled for monthly to semiannual sampling to monitor the pump-and-treat system. Two monthly samples were not collected.***
- ***Thirteen wells throughout the 100-H Area are scheduled for annual or biennial sampling. All wells were sampled as scheduled.***
- ***Thirty-two wells in the 600 Area between 100-D and 100-H Areas are scheduled for quarterly to biennial sampling. All were sampled as scheduled.***

***Facility Monitoring – 116-H-6 Solar Evaporation Basins (Appendix B)***

- ***Four downgradient wells are scheduled for annual sampling to meet RCRA and AEA requirements. All wells were sampled as scheduled.***

**Figure 2.6-1. Facilities and Groundwater Monitoring Wells in the 100-H Area.**

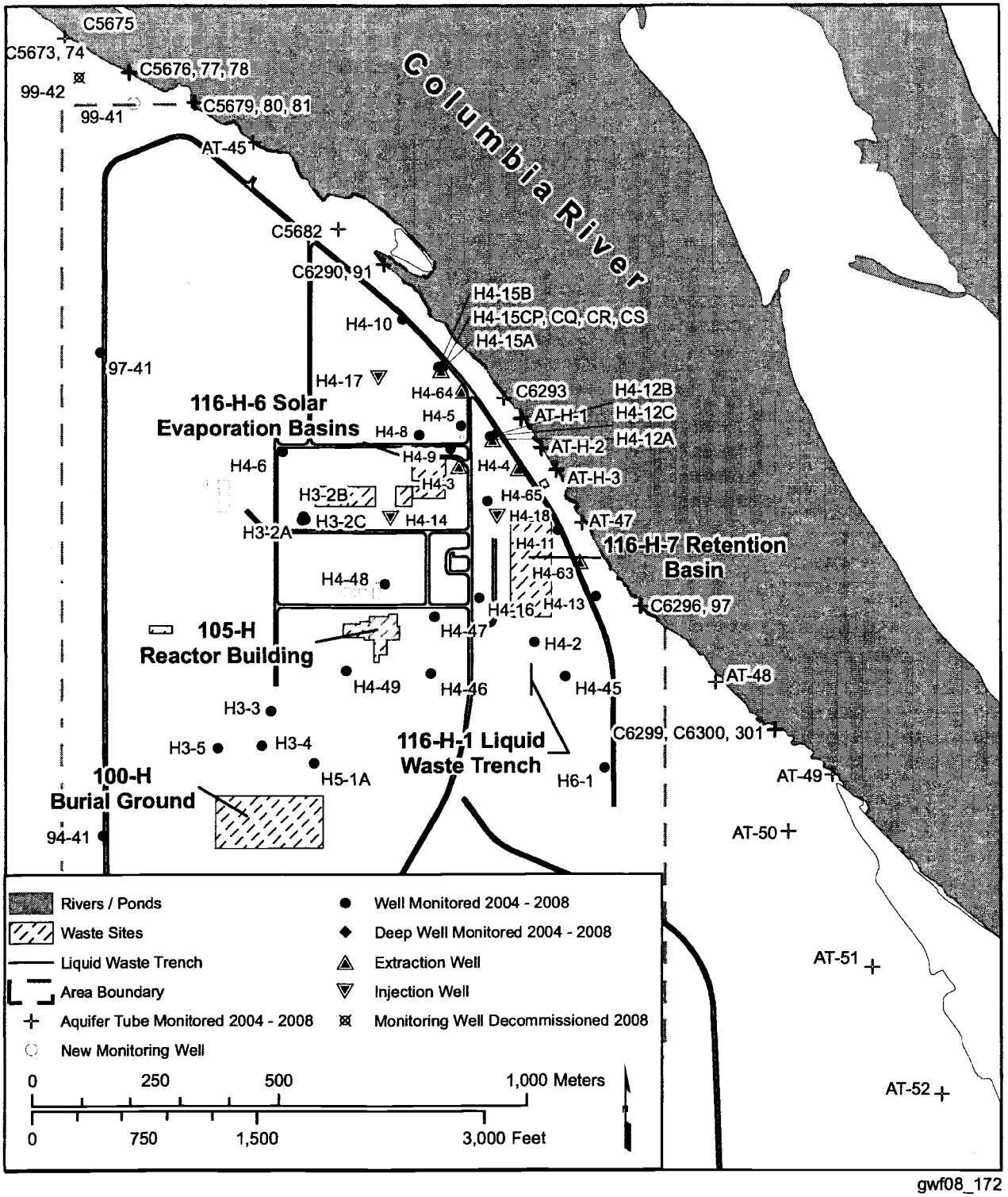


**Figure 2.6-2. 100-H Area Water-Table Map, March 2008.**

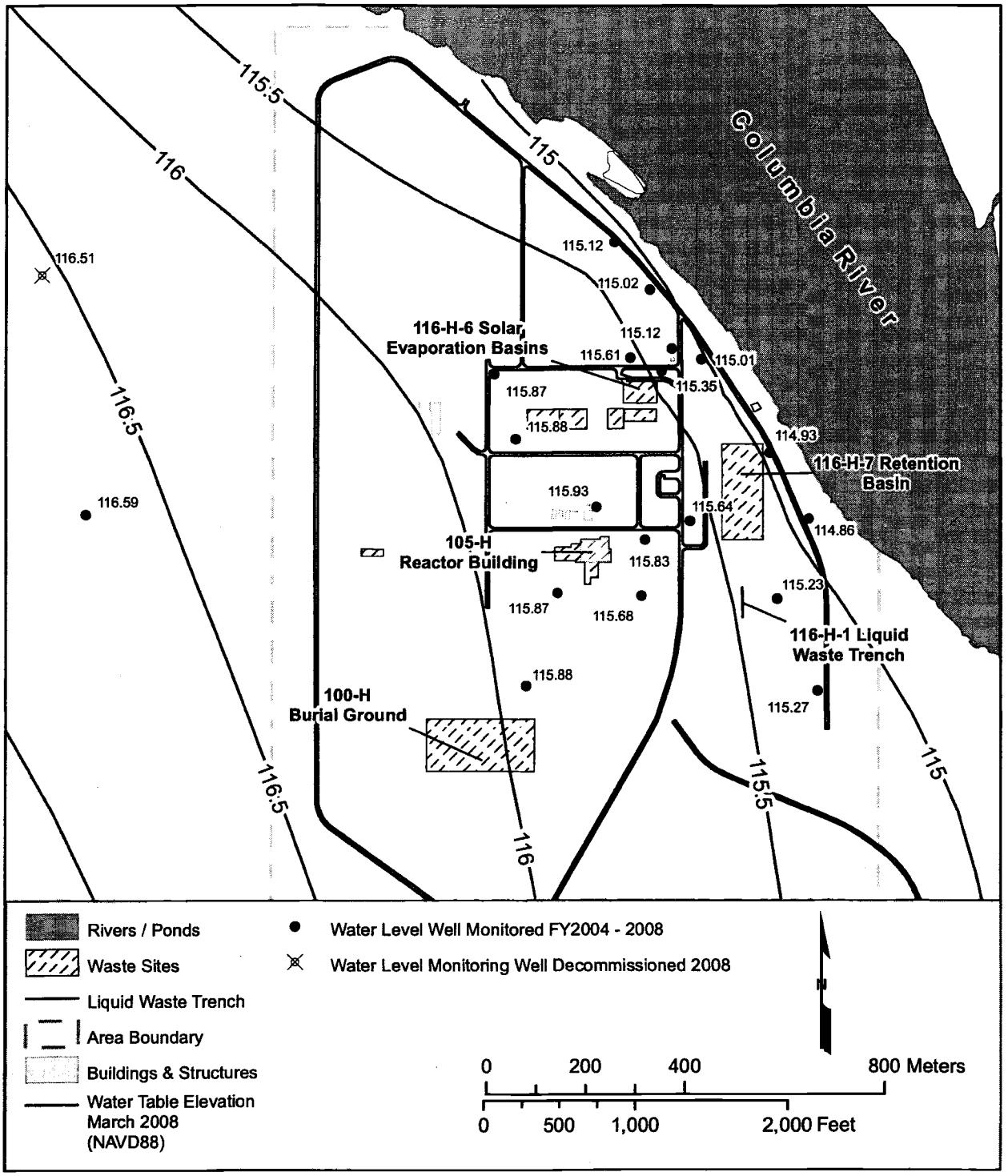


**Figure 2.6-3. Hexavalent Chromium Concentrations in 100-H Area Former Injection Wells.**

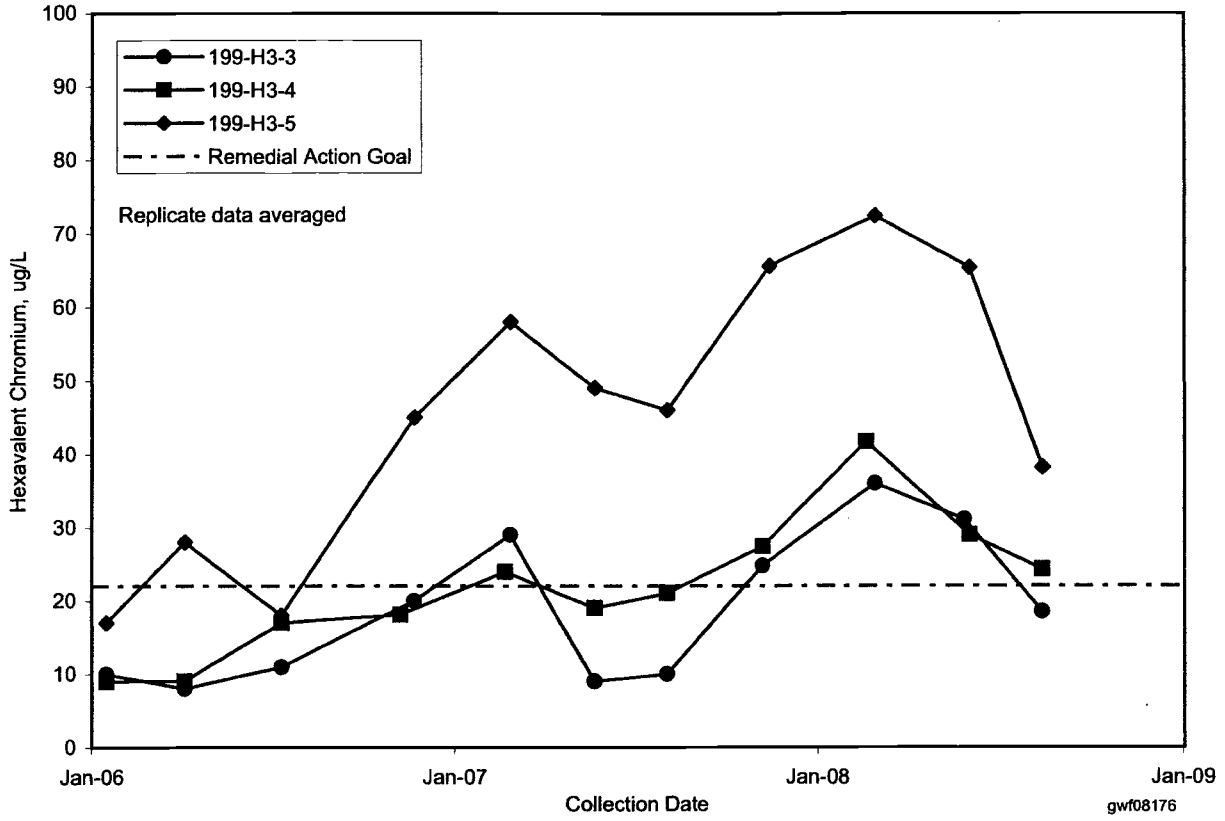



**Figure 2.6-4. Hexavalent Chromium Concentrations in Extraction Well 199-H4-3 and 100-H Area River Stage.**

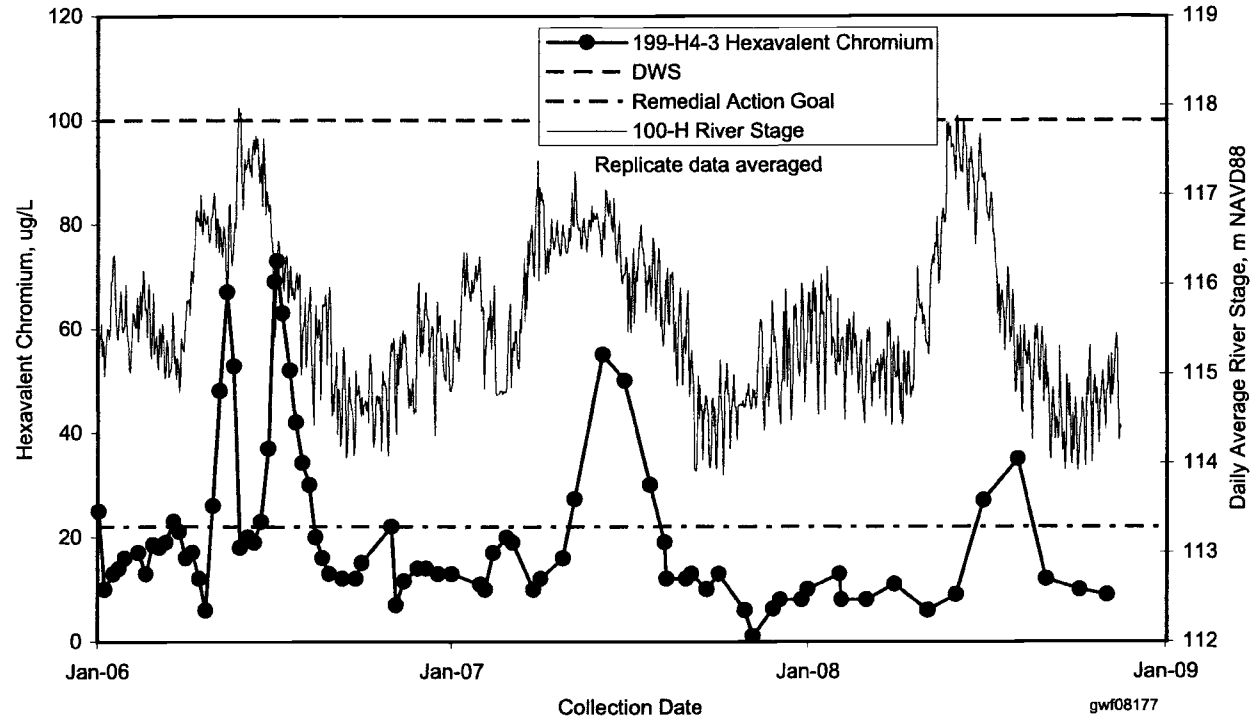


**Figure 2.6-5. Chromium Concentrations in Extraction Wells for the 100-HR-3 Pump-and-Treat System.**

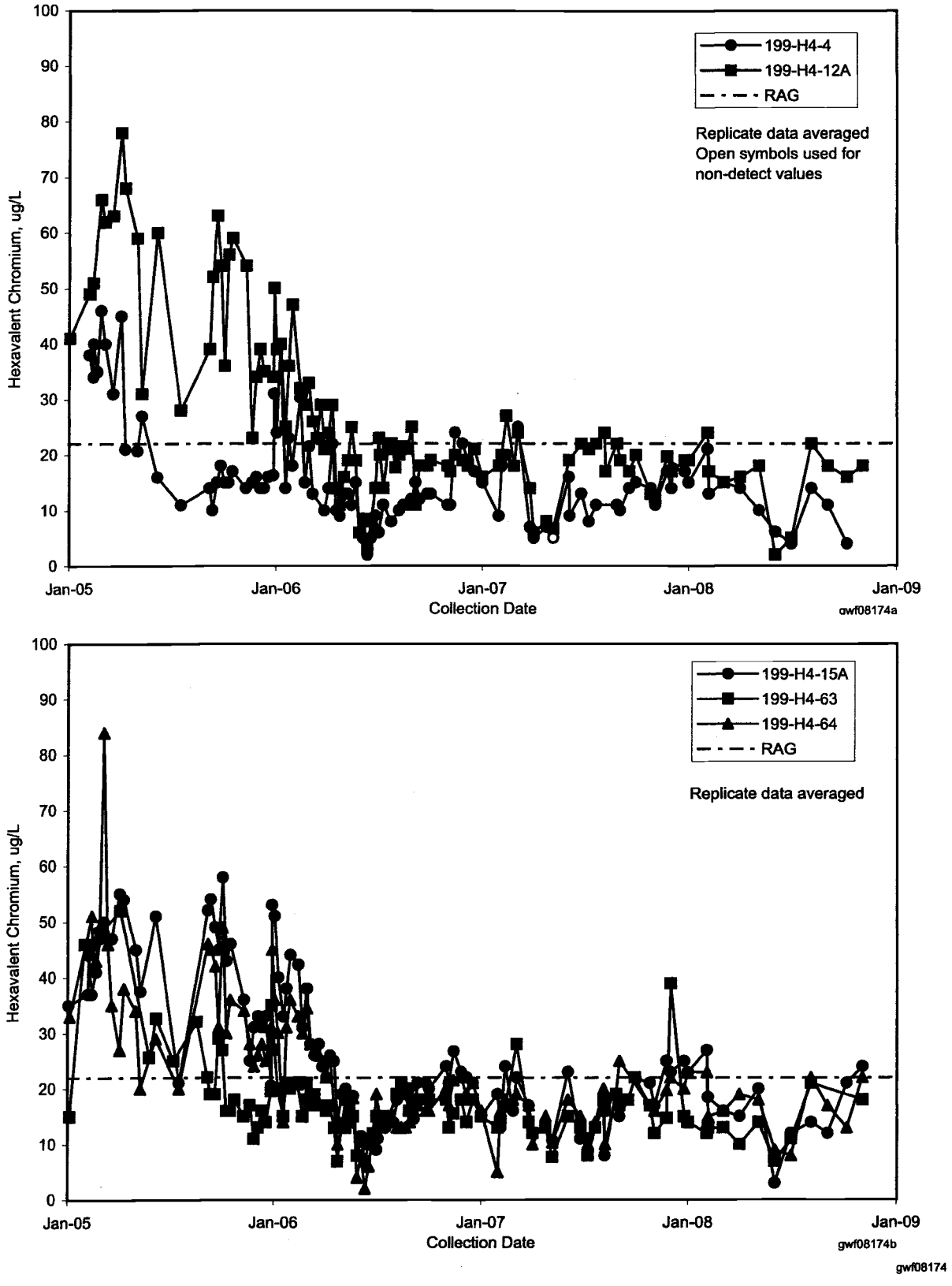
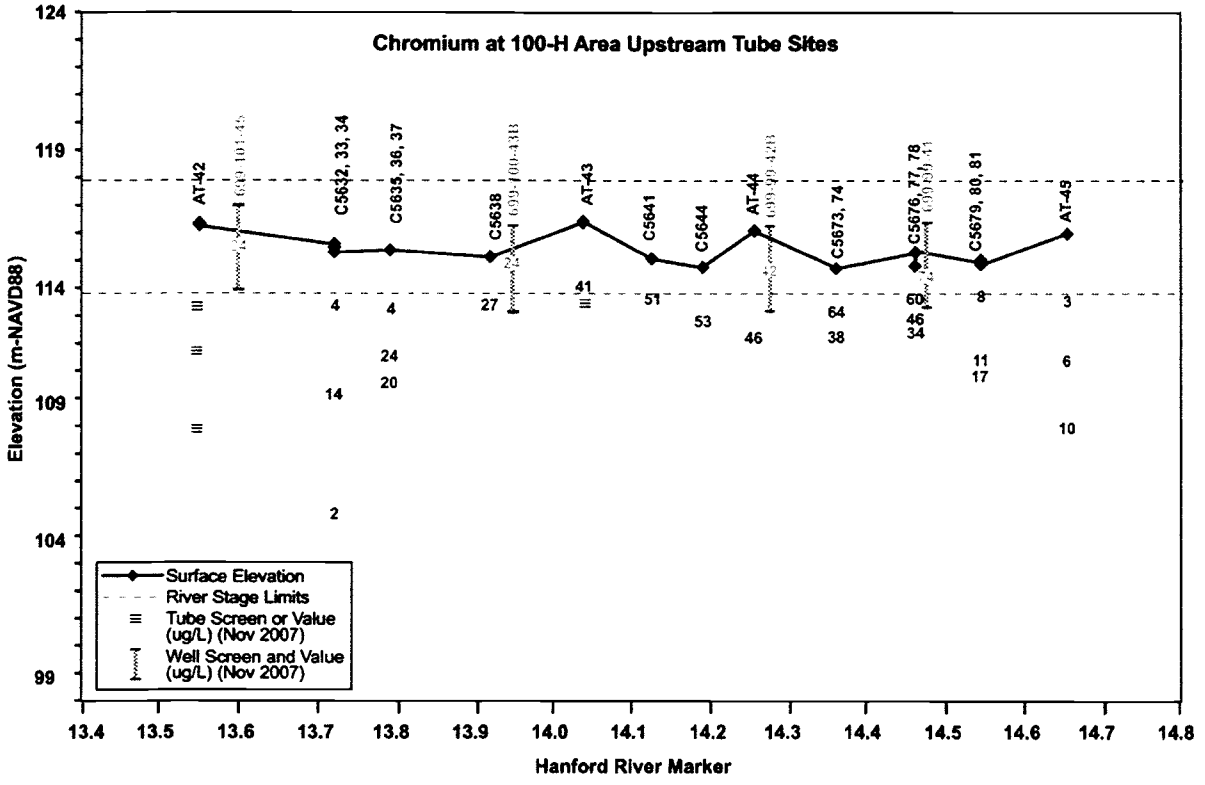
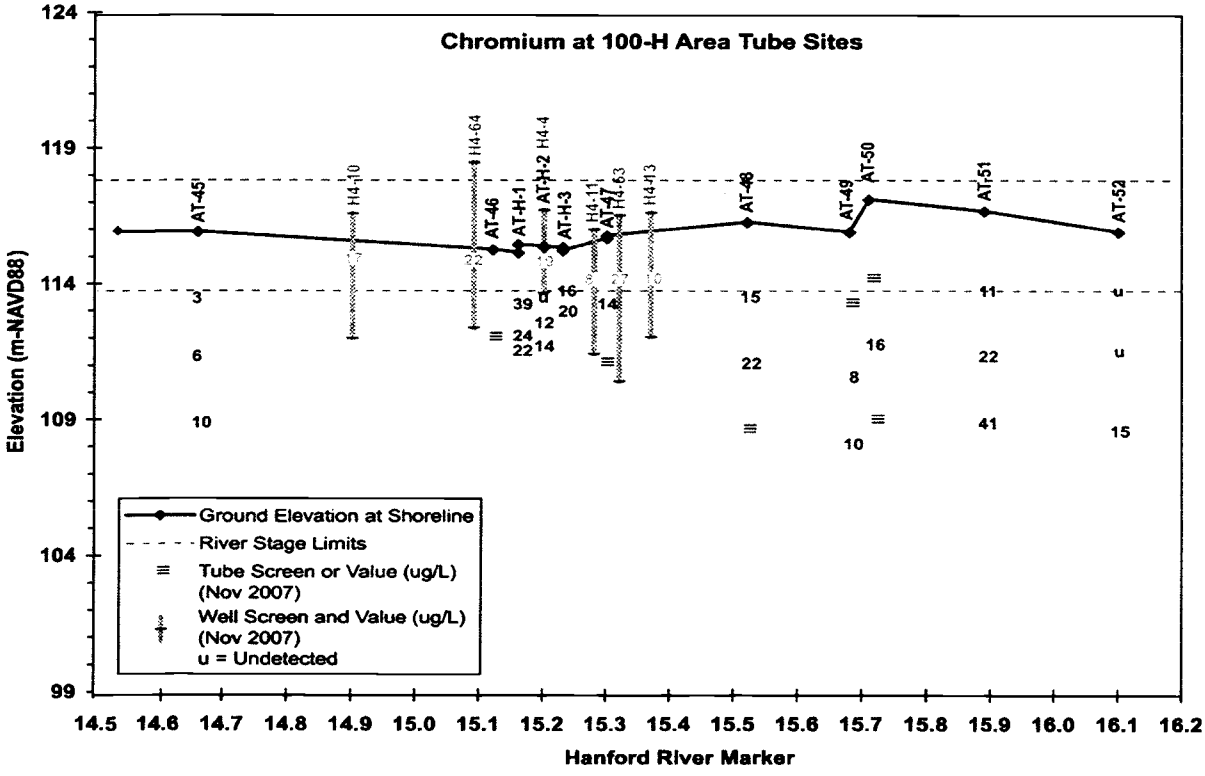


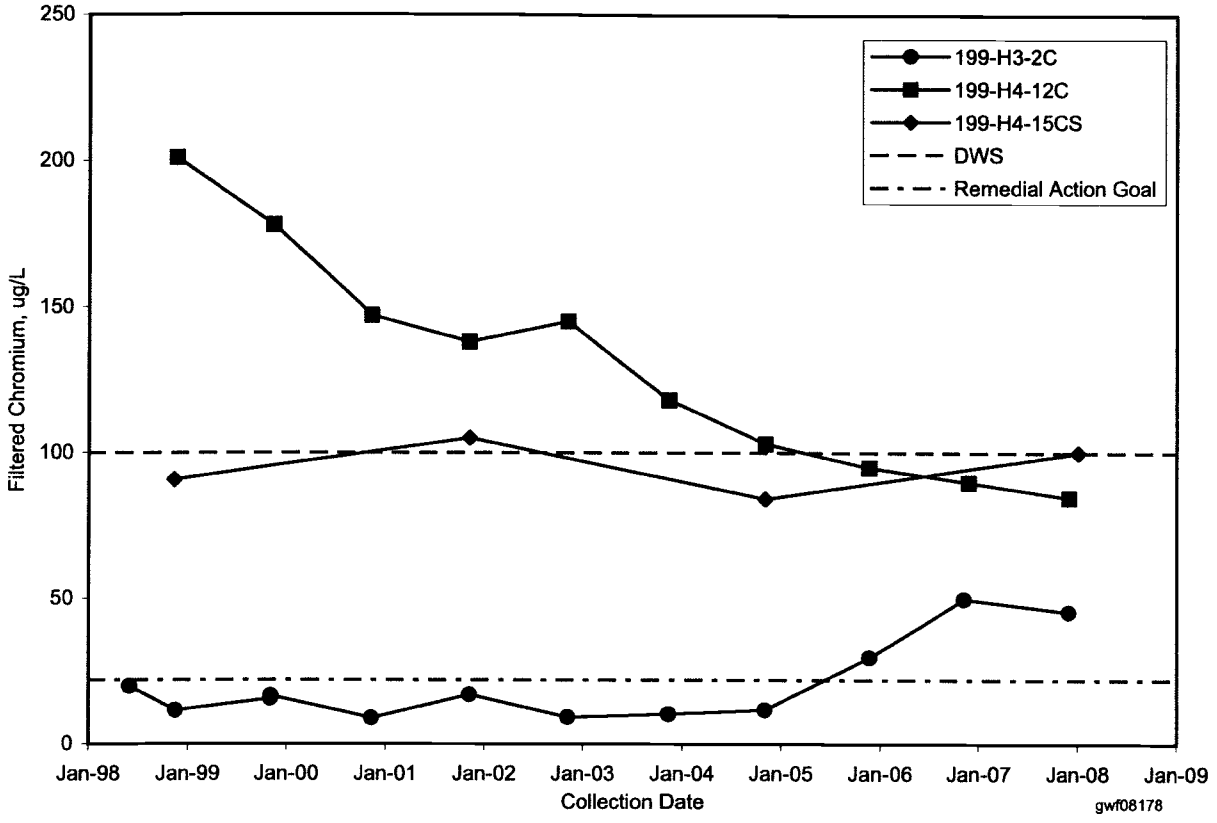
**Figure 2.6-6. Cross Section of Chromium Concentrations and Screen Elevations in Wells and Aquifer Tubes in the 100-H Area.**




gwf08_175

**Figure 2.6-7. Chromium Concentrations in Wells Monitoring the Confined Aquifer in the Ringold Upper Mud Unit.**



# 2.7 100-FR-3 Operable Unit

*M. J. Hartman*

This section describes groundwater flow and chemistry in the vicinity of the 100-F Area. The 100-FR-3 groundwater interest area encompasses the 100-FR-3 Operable Unit and a large section of the 600 Area north of Gable Mountain (Figure 1.0-1). Figure 2.7-1 shows facilities, wells, and shoreline monitoring sites in the 100-F Area.

Near the Columbia River, the direction of groundwater flow beneath the 100-F Area varies with river stage. Figure 2.7-2 shows the water table in March 2008 when the Columbia River was at a moderate level. The map indicates a flow direction toward the east-northeast in the northern part of the 100-F Area and toward the east-southeast in the southern part. The flow directions were the same in November 2007, a time that generally represents low groundwater conditions. The high river stage in June 2008 created a reversed gradient, with the potential for flow toward the southwest beneath part of the 100-F Area (Figure 2.7-3). However, farther from the river (e.g., near the 118-F-1 and 118-F-6 Burial Grounds) the groundwater flow direction remained toward the east-northeast.

There is an upward hydraulic gradient in the 100-F Area, based on evidence from wells 199-F5-43A (unconfined aquifer) and 199-F5-43B (Ringold upper mud unit). In March 2008 the gradient was 0.003.

Some of the main concepts associated with the 100-FR-3 Operable Unit include the following.

- Strontium-90, nitrate, hexavalent chromium, and trichloroethene plumes are present in groundwater at levels above drinking water or aquatic standards.
- Previous assessments have not identified groundwater conditions that warrant interim remedial measures. Final decisions on groundwater cleanup will be reached in coming years.
- One new well was installed to monitor groundwater near a recently-excavated burial ground.
- Most of the former waste sites have been remediated (shallow contaminated sediment has been excavated) and backfilled. Remediation is ongoing at remaining sites.
- All but one of the monitoring wells are screened at the top of the unconfined aquifer, which is ~9 m thick in the 100-F. One well is screened ~36 m below the water table in the Ringold upper mud unit, and it does not detect any contamination.

The following sections provide details about the operable unit activities. Sections 2.7.1 and 2.7.2 describe contaminant plumes and concentration trends for contaminants of concern and operable unit activities, respectively. Groundwater monitoring for the *Atomic Energy Act of 1954* (AEA) is integrated fully with *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) monitoring. Most of the former liquid waste sites in the 100-F Area have been excavated and backfilled. There are no active waste disposal facilities or *Resource Conservation and Recovery Act of 1976* sites in the 100-F Area.

## 2.7.1 Groundwater Contaminants

***Plume areas (square kilometers) in the 100-FR-3 Operable Unit:***

***Chromium, 20 µg/L — 0.12***
***Nitrate, 45 mg/L — 16.89***
***Strontium-90, 8 pCi/L — 0.16***
***Trichloroethene, 5 µg/L — 0.64***

Wells in the 100-FR-3 Operable Unit are sampled for the contaminants of concern provided in DOE/RL-2003-49, *100-FR-3 Operable Unit Sampling and Analysis Plan*: nitrate, strontium-90, tritium, trichloroethene, uranium, gross alpha, and hexavalent chromium. This section describes distribution and trends of the groundwater contaminants of concern beneath the 100-FR-3 groundwater interest area.

### 2.7.1.1 Nitrate

A large nitrate plume extends southward ~5 km from the 100-F Area, although data are sparse in the 600 Area (Figure 1.0-3). The plume did not change significantly between fiscal year (FY) 2007 and FY 2008.

Wells in the main 100-F Area continued to show levels of nitrate that exceeded the drinking water standard (45 mg/L) in FY 2008. The highest FY 2008 nitrate concentration was 114 mg/L in well 199-F7-3, located in southwestern 100-F Area (Figure 2.7-4). Overall, concentrations in the wells within the nitrate plume are steady or declining.

Nitrate concentrations in 100-F Area aquifer tubes were below the drinking water standard in FY 2008, but above background. The concentration increased to 40.9 mg/L in aquifer tube AT-62-M, north of 100-F Area (Figure 2.7-5). This was the highest observed at that location to date. Located upstream from this tube, monitoring well 199-F1-2 has nitrate concentrations at ~30 mg/L. Aquifer tube AT-75-D, located south of the 100-F Area, historically has nitrate levels above the drinking water standard; however, the concentration was 40.6 mg/L in FY 2008.

### 2.7.1.2 Strontium-90

Strontium-90 concentrations exceed the drinking water standard (8 pCi/L) beneath the portion of the 100-F Area around the 116-F-14 Retention Basin and nearby disposal trenches (Figure 2.7-6). The extent of the plume has not changed significantly for more than 10 years. In FY 2008, well 199-F5-1 had the highest strontium-90 concentration (25.8 pCi/L). Strontium-90 also exceeded the drinking water standard in well 199-F5-46 (8.25 pCi/L). A few other wells had detectable strontium-90, but concentrations were below the drinking water standard (Figure 2.7-6). Overall, the trends are neither increasing nor decreasing.

During remediation of the 118-F-6 Burial Ground, the excavation reached the water table in one location and a small puddle of water formed (the water table is only 6 to 8 m below the surface in the southwestern 100-F Area). In one water sample, strontium-90 was detected in hundreds of picocuries per liter. A second sample also had elevated strontium-90. In FY 2008, the U.S. Department of Energy (DOE) installed a new monitoring well, 199-F8-7. Preliminary results from FY 2009 showed low, detectable concentration of strontium-90. The well will be sampled quarterly for strontium-90 and other constituents in FY 2009.

Strontium-90 shows vertical stratification in the only shallow/deep well pair in the 100-F Area. Deep well 199-F5-43B consistently has no detectable strontium-90, while its shallow counterpart, well 199-F5-43A, typically detects 2 to 4 pCi/L of strontium-90. Strontium-90 concentrations also tend to be higher in shallow aquifer tubes than in deeper aquifer tubes, but all results for FY 2008 were below

the 8 pCi/L drinking water standard. The maximum concentration was 4.4 pCi/L in aquifer tube C6302. This is the shallower of a pair of tubes, but the adjacent, deeper tube (C6303) was not sampled for strontium-90.

### 2.7.1.3 Tritium

Although elevated, tritium concentrations beneath the southern 100-F Area do not exceed the drinking water standard (20,000 pCi/L). The plume extends to the southeast into the 600 Area at concentrations above 2,000 pCi/L.

Historically, only well 199-F8-3, near the 118-F-1 Burial Ground, has exceeded the tritium drinking water standard. In the mid-1990s, concentrations at this well were nearly 180,000 pCi/L. Concentrations have declined, and the concentration was 15,000 pCi/L in FY 2008. The decline cannot be accounted for by radioactive decay. The contamination apparently is moving downgradient toward the south, where well coverage is sparse. Tritium concentrations in well 699-71-30, located ~1.5 m south of the 100-F Area, are below detection limits. Concentrations in aquifer tubes along the southern shoreline are low (hundreds of picocuries per liter).

### 2.7.1.4 Trichloroethene

***Although above the drinking water standard, trichloroethene concentrations are declining in southwestern 100-F Area.***

Trichloroethene concentrations in the southwestern 100-F Area exceed the drinking water standard (5 µg/L) but are declining. The plume appears to be centered west of the 100-F Area. A soil-gas investigation (DOE/RL-95-99, *100-FR-3 Groundwater/ Soil Gas Supplemental Limited Field Investigation Report*) helped define the area of contamination but did not identify the source of contamination. In FY 2008, trichloroethene concentrations continued to decline, with only two wells exceeding the drinking water standard (Figure 2.7-7). The highest concentration was 9.7 µg/L in well 199-F7-1.

### 2.7.1.5 Uranium and Gross Alpha

Uranium concentrations in 100-F Area groundwater remained below the drinking water standard (30 µg/L). Four wells were sampled for uranium in FY 2008 and the maximum concentration was 17.6 µg/L in well 199-F8-4 in the southeastern 100-F Area. This well also had the highest gross alpha concentration, 12 pCi/L. The drinking water standard for gross alpha is 15 pCi/L.

### 2.7.1.6 Chromium

***Chromium concentrations in 100-F Area groundwater remained below the drinking water standard in FY 2008.***

Hexavalent chromium is of potential concern to salmon and other aquatic life. The aquatic standard for hexavalent chromium is 10 µg/L. Chromium concentrations in groundwater beneath the 100-F Area are below the drinking water standard (100 µg/L for total chromium), but some exceed the aquatic standard. Three wells, located near the 116-F-14 Retention Basins and the 116-F-9 Trench, had levels above 20 µg/L in recent data (Figure 2.7-8). The highest chromium concentrations in the groundwater interest area were in well 699-83-47, located west of the 100-F Area (Figure 2.1-1). The FY 2008 results were 51.8 µg/L in an unfiltered sample and 42.5 µg/L in a filtered sample. The highest chromium concentrations within the 100-F Area were in well 199-F5-6 (49.7 µg/L for unfiltered and 41.0 µg/L for filtered samples). Figure 2.7-9 shows chromium trends in the three wells with the highest concentrations. Levels have declined since 2002 or 2003 in wells 199-F5-6 and 199-F5-46, and have increased slightly in well 199-F5-44.

Chromium levels are low in 100-F Area aquifer tubes. Excluding erroneous data, the highest hexavalent chromium concentration was 11.9 μg/L in AT-75-D, which is downstream from the 100-F Area.

## 2.7.2 Operable Unit Activities

Groundwater sampling requirements are defined in the groundwater sampling and analysis plan (DOE/RL-2003-49) and a Tri-Party Agreement change notice (TPA-CN-228). The change notice, approved in July 2008, added a new well to the network. Well 199-F8-6 was installed near the 118-F-6 Burial Ground. All of the wells scheduled for sampling in FY 2008 were sampled successfully. Three of the aquifer tube sites were not sampled because the tubes had been destroyed or could not be located (Appendix A). Two seeps could not be sampled; seep sampling depends on field conditions and is not always possible.

The DOE installed 12 new aquifer tubes in FY 2008. Results from the new tubes and the older tubes were similar.

***Groundwater monitoring in the 100-FR-3 groundwater interest area includes integrated CERCLA and AEA monitoring.***

- ***Thirty-four wells are scheduled for annual or biennial sampling.***
- ***Fourteen aquifer tube sites and three seeps are scheduled for annual sampling. Three aquifer tube sites and two seeps could not be sampled in FY 2008.***
- ***The DOE installed one well and 12 aquifer tubes in FY 2008.***

**Figure 2.7-1. Facilities and Groundwater Monitoring Wells in the 100-F Area.**

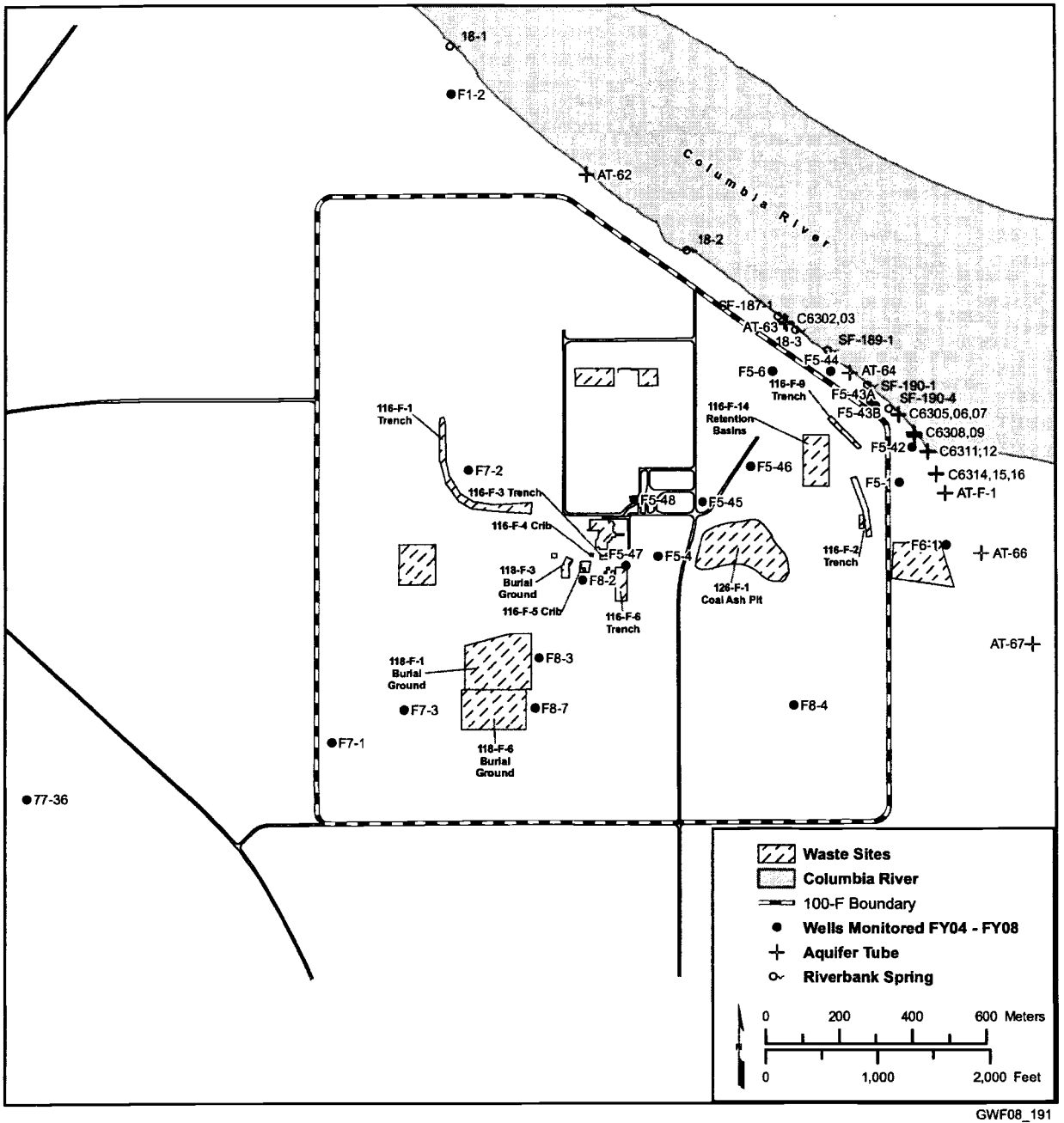


**Figure 2.7-2. 100-F Area Water-Table Map, March 2008.**

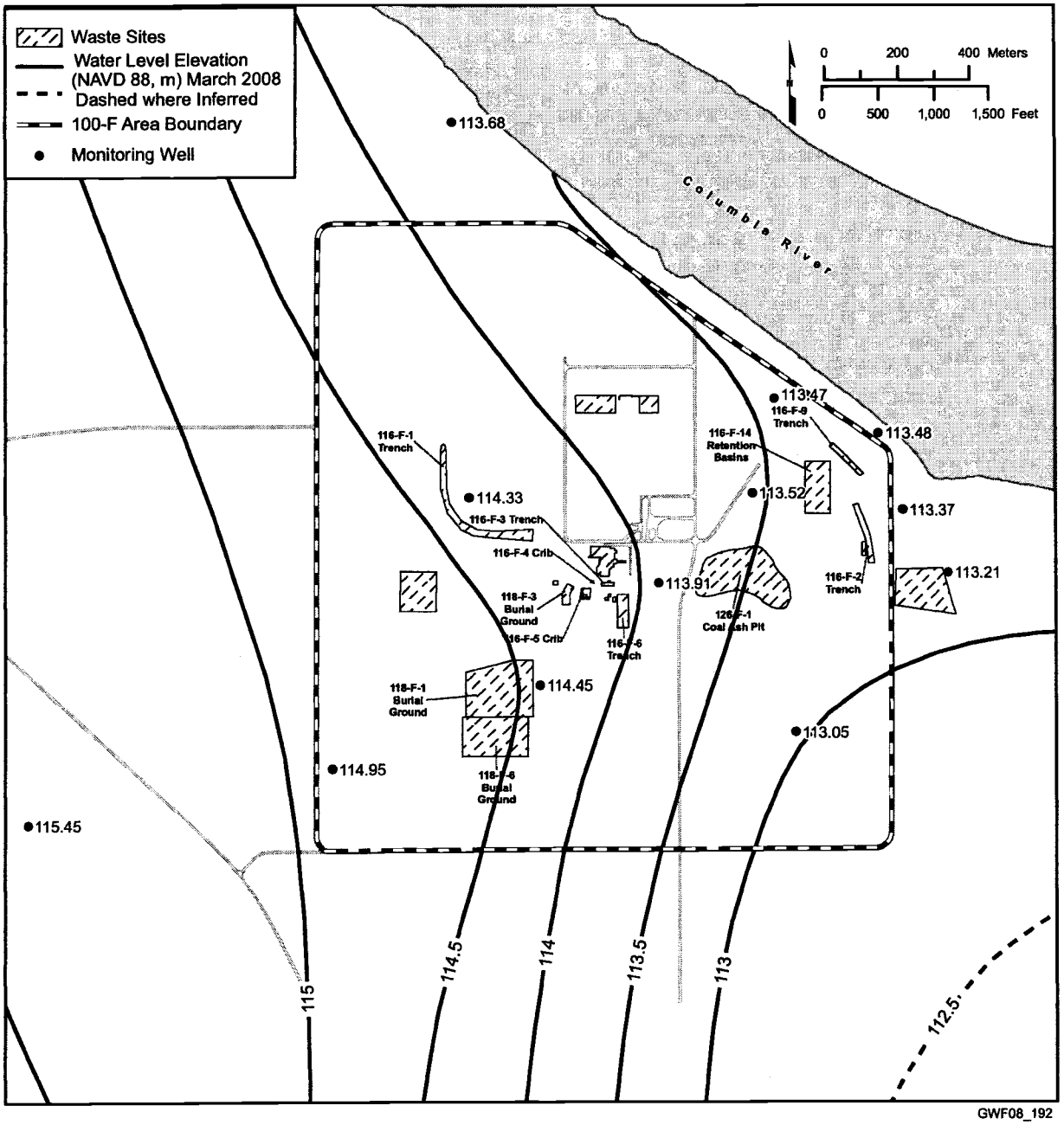


**Figure 2.7-3. 100-F Area Water-Table Map, June 2008.**

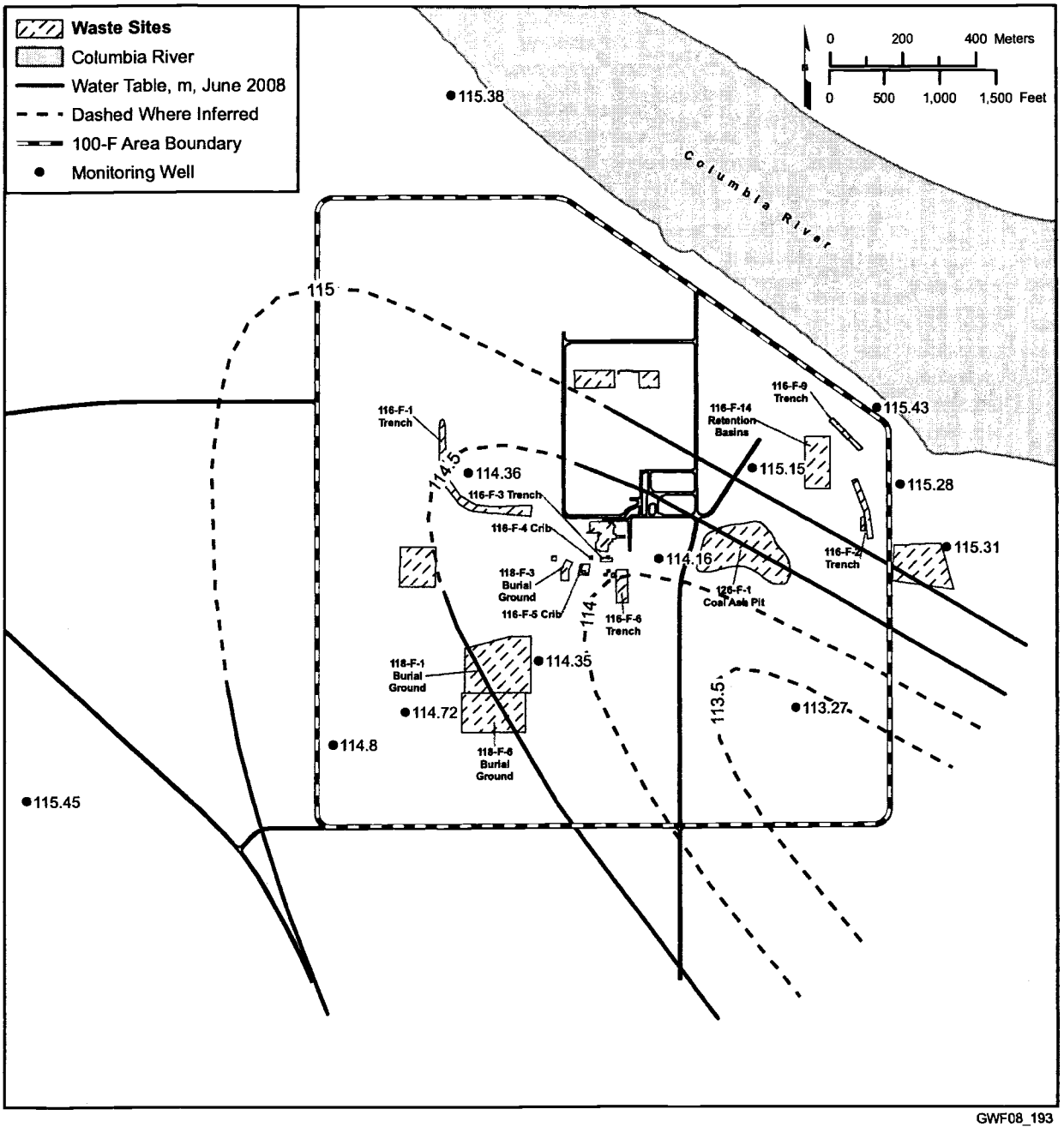


**Figure 2.7-4. Nitrate Concentrations in Southwestern 100-F Area.**

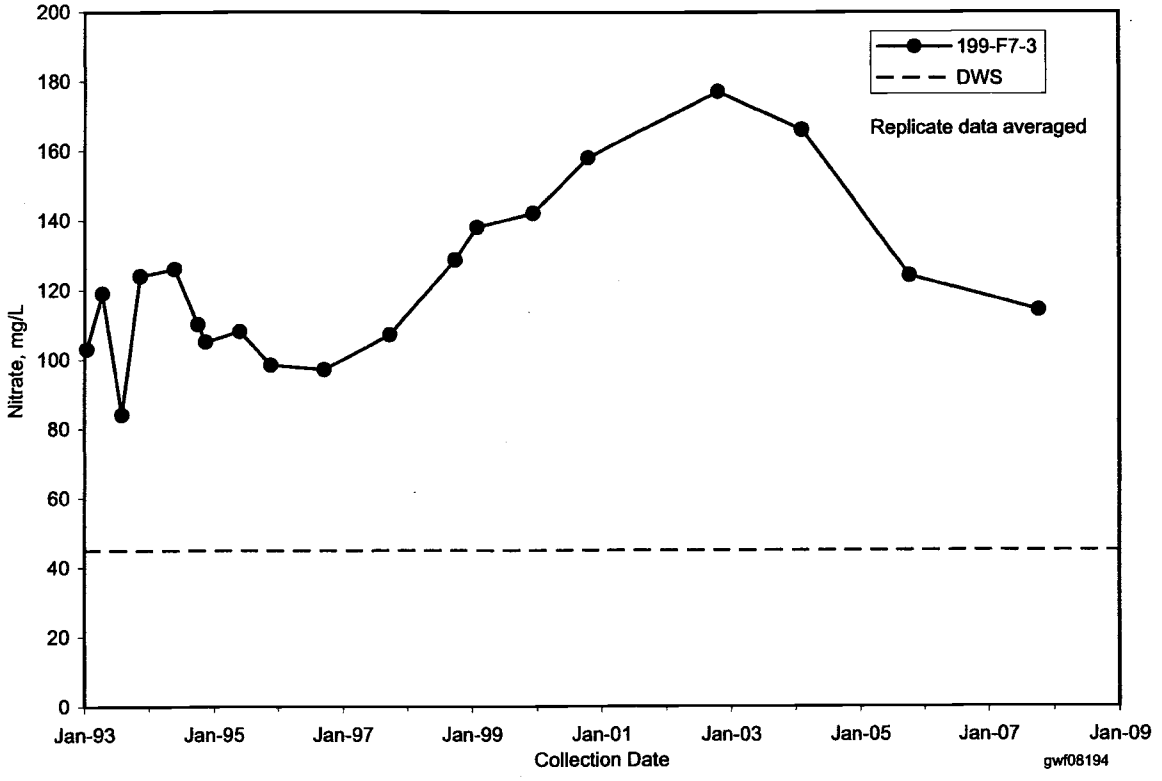



**Figure 2.7-5. Nitrate Concentrations in Aquifer Tubes Upstream (62-M) and Downstream (75-D) of 100-F Area.**

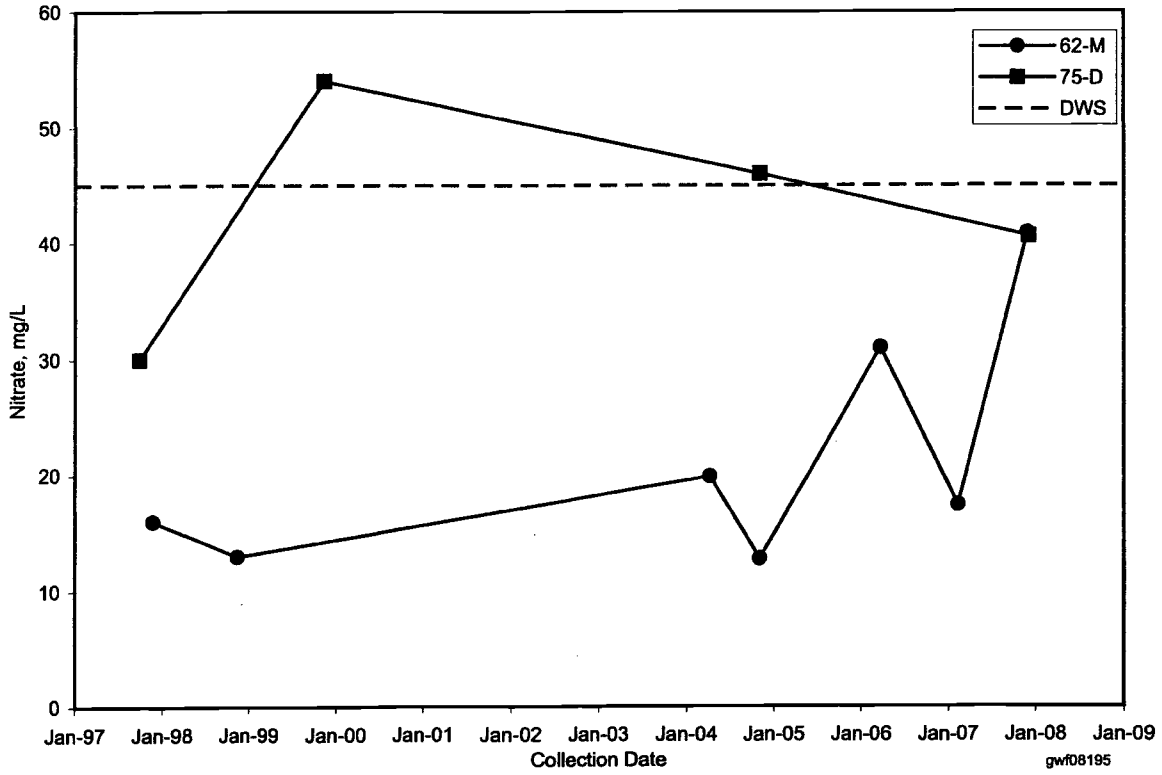


**Figure 2.7-6. Average Strontium-90 Concentrations in the 100-F Area, Upper Part of Unconfined Aquifer.**

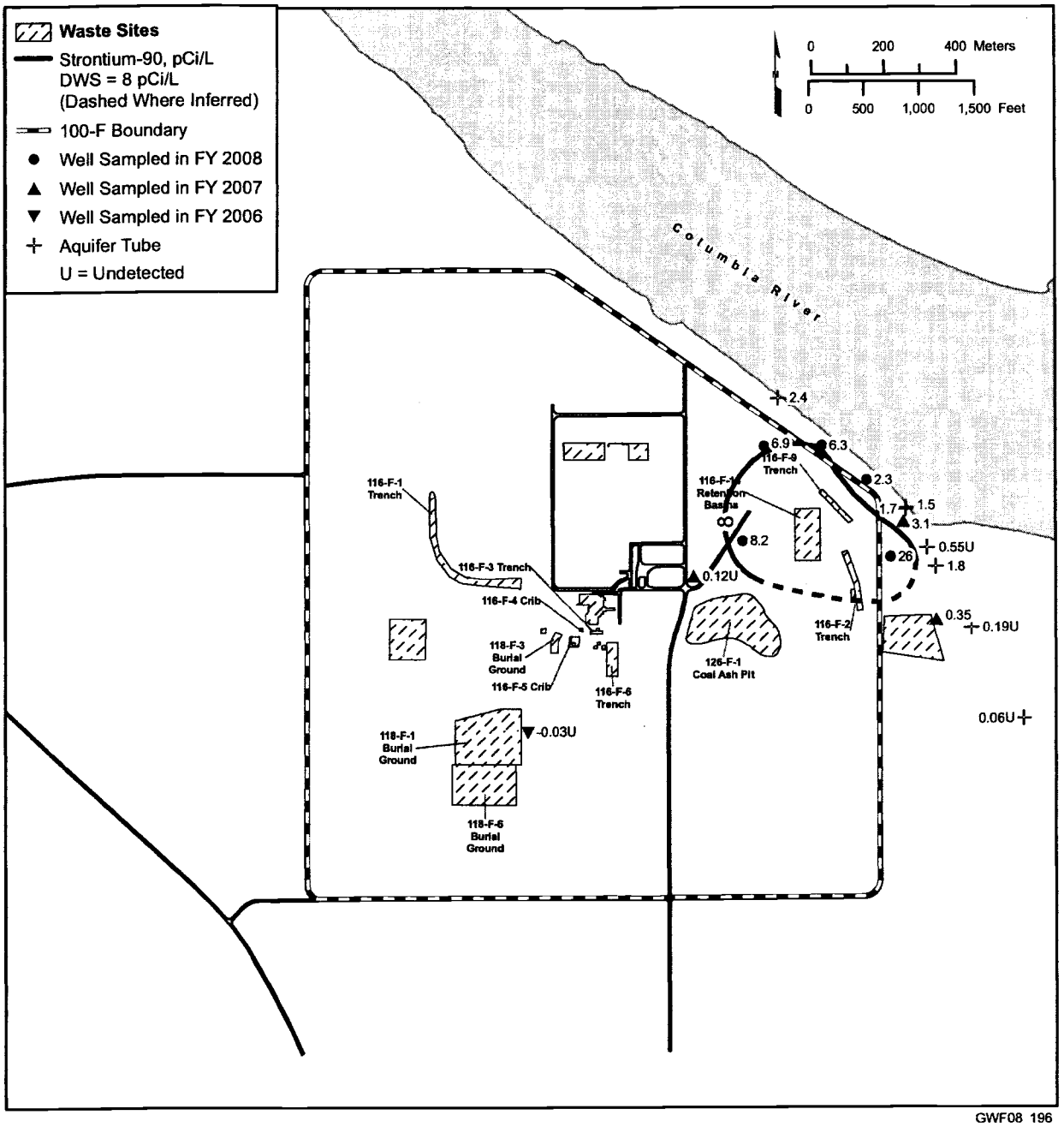


**Figure 2.7-7. Trichloroethene Concentrations in Southwestern 100-F Area.**

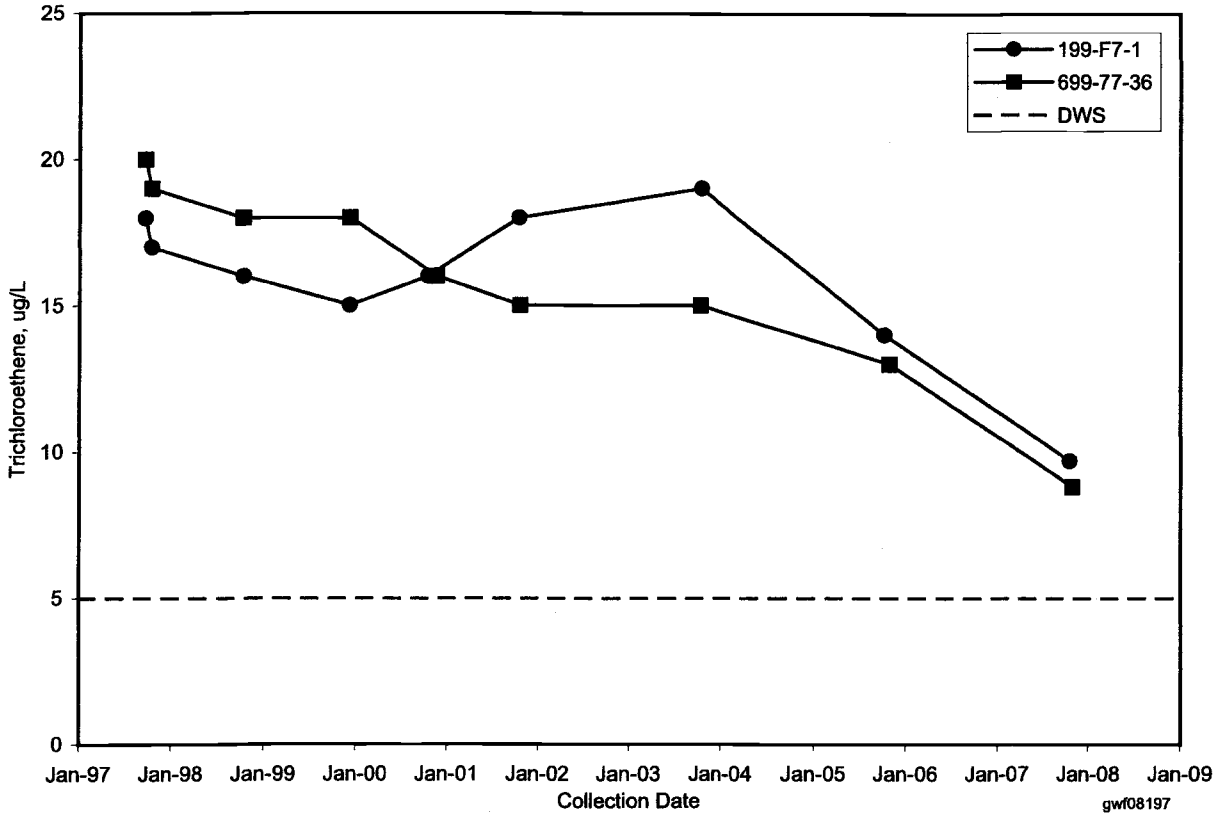


**Figure 2.7-8. Average Chromium Concentrations in the 100-F Area, Upper Part of Unconfined Aquifer.**

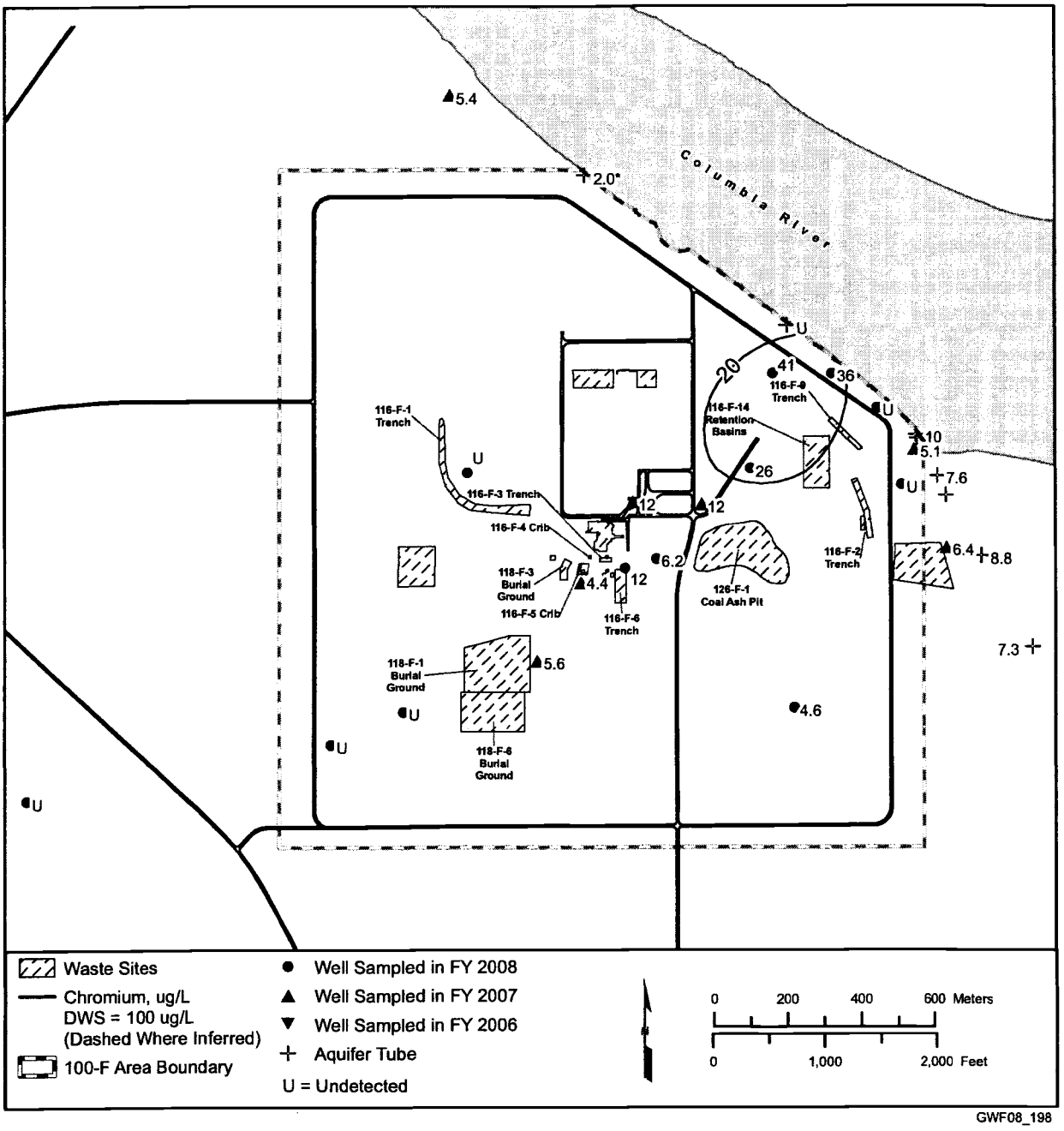
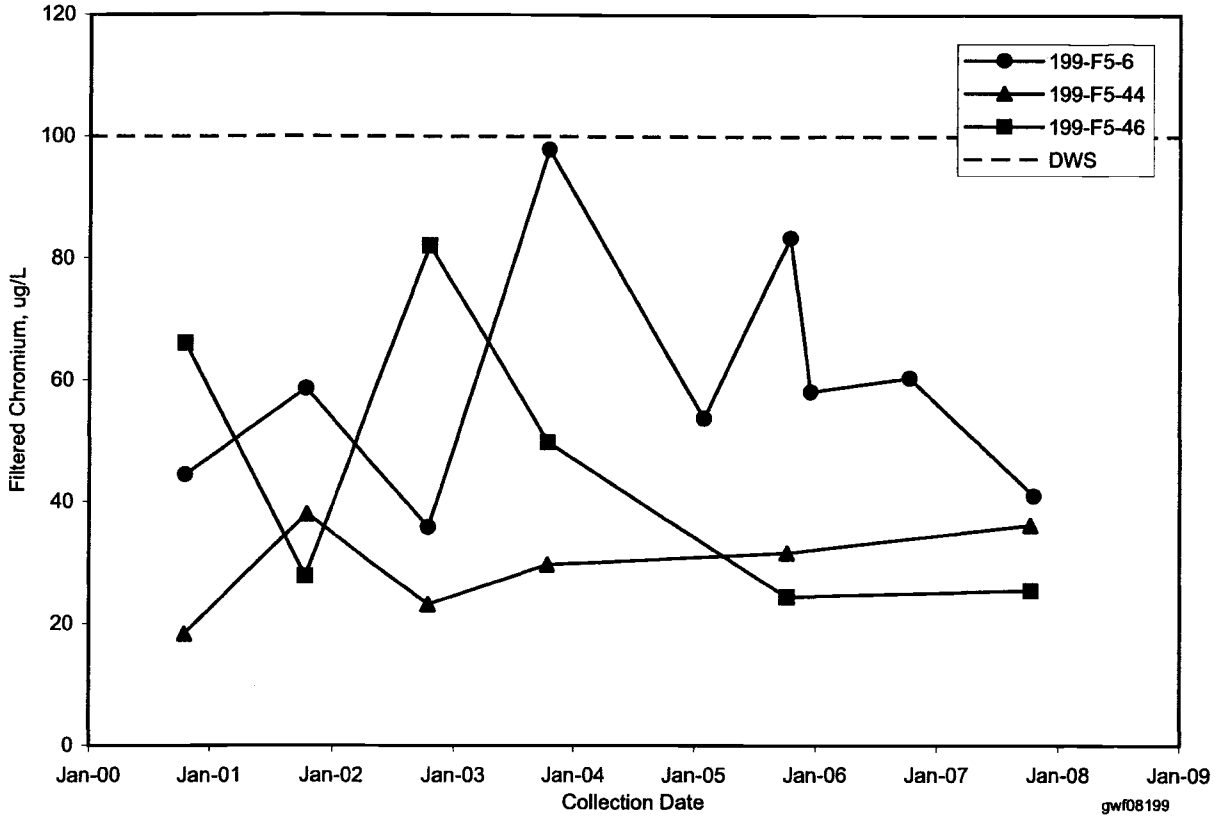


**Figure 2.7-9. Chromium Concentrations in the 100-F Area.**



# 2.8 200-ZP-1 Operable Unit

*R. L. Biggerstaff*

The 200-ZP-1 Operable Unit addresses groundwater contaminant plumes beneath the northern and central parts of the 200 West Area and the western 600 Area. The operable unit lies within the larger 200-ZP-1 groundwater interest area, informally defined to facilitate scheduling, data review, and interpretation (Figure 1.0-1). Figure 2.8-1 shows facilities and wells in this region.

Groundwater in the north portion of the 200 West Area predominantly flows toward the east-northeast, but is locally influenced by the 200-ZP-1 Pump-And-Treat System and effluent discharges to the State-Approved Land Disposal Site (Figure 2.8-2). The groundwater flow rates typically range from 0.0001 to 0.5 m/day within the 200-ZP-1 groundwater interest area. However, flow rates and gradients in proximity to the extraction and injection wells will be substantially greater. The water table continues to decline at a rate of approximately 0.21 m/yr. The water table in the 200 West Area was influenced by past discharge of wastewater and the aquifer is still re-equilibrating after the termination of discharges. The flow direction in the northern part of the groundwater interest area has changed ~35° over the past decade from a north-northeastern direction to a more eastern direction, but the changes from year to year are becoming less apparent as the water returns to natural groundwater levels.

***The groundwater flow direction has changed ~35 degrees over the past decade, but the changes from year to year are becoming less apparent as the natural groundwater levels are approached.***

Flow in the central part of the 200 West Area (southern part of the 200-ZP-1 groundwater interest area) is strongly influenced by the operation of the 200-ZP-1 Pump-And-Treat System. Four monitoring wells (299-W15-1, 299-W15-7, 299-W15-11, and 299-W15-46) were converted to extraction wells in fiscal year (FY) 2008. The 200-ZP-1 Pump-and-Treat System has 14 extraction wells in the vicinity of the primary cribs and trenches and west of Waste Management Area (WMA) TX-TY (Figure 2.8-1). The treatment system removes carbon tetrachloride and other volatile organic compounds. Treated effluent is re-injected into the aquifer to the west of the area. A small groundwater mound is associated with the injection wells, and a region of draw down is associated with the extraction wells, causing flow to converge on the extraction zone from all directions. The injection wells, which are due west of Low-Level WMA 4, also have affected groundwater flow and contaminant concentrations beneath this facility (Appendix B).

Some of the main concepts associated with the 200-ZP-1 Operable Unit include the following.

- Principal sources of groundwater contamination included former cribs, trenches, and single-shell tank farms that formerly leaked. These facilities are currently inactive, and pumpable liquids have been removed from the tanks. However, the waste sites have not yet been remediated and contamination remains in the vadose zone.
- Active waste sites include the Low-Level Burial Grounds and the State-Approved Land Disposal Site, where tritium-contaminated water is discharged.
- In September 2008, the U.S. Department of Energy (DOE), U.S. Environmental Protection Agency (EPA), and Washington State Department of Ecology (Ecology) signed a final record of decision for groundwater remediation, which will include pump-and-treat and flow-path control.

- Carbon tetrachloride is the principal contaminant of concern in groundwater and exceeds the drinking water standard (5 μg/L) under most of the operable unit. The high-concentration center of the plume has shrunk, but the margins of the plume continued to spread.
- Other groundwater contaminants include trichloroethene, chloroform, nitrate, fluoride, chromium, iodine-129, technetium-99, and tritium. The size of the trichloroethene plume has decreased and the concentrations are declining.
- The distribution of carbon tetrachloride with depth is complex and not well characterized. Drilling activities to date have not identified any significant dense, non-aqueous phase liquid contamination. Depth-discrete sampling in new wells has helped define the vertical distribution of contaminants. The highest concentrations of carbon tetrachloride and other contaminants is not always near the top of the aquifer.
- An interim action pump-and-treat system removed 461.5 kg of carbon tetrachloride in FY 2008 and over 11,000 kg since 1994. Four monitoring wells were converted to extraction wells to enhance removal of carbon tetrachloride.
- A vapor extraction system has removed over 79,000 kg of carbon tetrachloride since 1991, preventing it from reaching groundwater.
- A small pump-and-treat system near WMA T removed 23.8 g of technetium-99 in FY 2008. Aquifer testing was conducted to aid in locating future technetium-99 extraction wells.
- Four *Resource Conservation and Recovery Act of 1976* (RCRA) sites are located in the 200-ZP-1 Operable Unit. At Low-Level WMA 4, total organic carbon concentrations in a downgradient well exceeded the critical mean value in August 2008. The site will be monitored under an assessment program in FY 2009.
- Statistical evaluations have been suspended at Low-Level WMA 3 because the site has no upgradient wells. Emplacement of new wells has been postponed until the effects of the expanded pump-and-treat system for carbon tetrachloride are evaluated.
- RCRA monitoring at WMAs T and TX-TY continued under assessment programs.

Groundwater is monitored to assess the performance of the interim action pump-and-treat system for carbon tetrachloride contamination, to track other contaminant plumes, and to support four RCRA units and the State-Approved Land Disposal Site. Data from facility-specific monitoring also are integrated into the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) groundwater investigations. Section 2.8.1 describes contaminant plumes and concentrations. Section 2.8.2 summarizes operable unit activities. Section 2.8.3 discusses groundwater monitoring of facilities under CERCLA, RCRA, state permits, and the *Atomic Energy Act of 1954* (AEA).

## 2.8.1 Groundwater Contaminants

Several areas of groundwater contamination are monitored in the 200-ZP-1 groundwater interest area. Wells in the 200-ZP-1 groundwater interest area are sampled for constituents based on the final remedy (EPA, 2008, *Declaration of the Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington*), which identifies carbon tetrachloride as the principal contaminant of concern. Other contaminants are trichloroethene, chloroform, nitrate, chromium, fluoride, tritium, iodine-129, technetium-99, and uranium. Additional contaminants are detected but at lower levels or in less extensive areas.

***Plume areas (square kilometers) above the drinking water standard in the 200-ZP-1 Operable Unit:***

****Carbon tetrachloride — 11.15***
***Chromium — 0.05***
***Iodine-129 — 0.75***
***Nitrate — 6.09***
***Technetium-99 — 0.08***
***Trichloroethene — 0.09***
***Tritium — 0.75***
***Uranium — 0.09***

****Also includes portion of plume beneath 200-UP-1 Operable Unit.***

The goal of the final remedy is to design and implement a remediation system to remove the principal contaminant of concern, carbon tetrachloride, and seven additional contaminants (chromium [total], hexavalent chromium, iodine-129, nitrate, technetium-99, trichloroethene, and tritium), throughout the vertical extent of the unconfined aquifer. Groundwater contamination is widely dispersed in the 200-ZP-1 Operable Unit and consists of overlapping contaminant plumes (i.e., all of the highest concentrations or the lowest concentrations do not necessarily occur at the same location), and, depending on contaminant density, can be present from the top to the base of the unconfined aquifer.

### 2.8.1.1 Carbon Tetrachloride

***Carbon tetrachloride is the principal contaminant of concern in the 200-ZP-1 Operable Unit.***

Carbon tetrachloride is the principal contaminant of concern for the 200-ZP-1 Operable Unit and is found at levels greater than the drinking water standard (5 µg/L) in the groundwater under most of the 200 West Area (Figure 2.8-3). This figure represents carbon tetrachloride contamination in the upper part of the unconfined aquifer (~15 m). The 200-ZP-1 Operable Unit feasibility study (DOE/RL-2007-28, *Feasibility Study for the 200-ZP-1 Groundwater Operable Unit*) includes illustrations showing the areal extent of the carbon tetrachloride plume at different depths. The maximum extent of the plume at all depths (i.e., the footprint of the plume) extends beyond the contours shown on Figure 2.8-3, particularly to the north and east of the 200 West Area. The main sources of carbon tetrachloride are three of the primary cribs and trenches that received waste from the Plutonium Finishing Plant. Carbon tetrachloride is present primarily in two phases in the subsurface beneath the 200-ZP-1 Operable Unit: gaseous and dissolved in groundwater. Both of these phases migrate uniquely in the sediments beneath this operable unit. Active and passive systems have been extracting gaseous carbon tetrachloride from the vadose zone (unsaturated zone overlying groundwater), for many years and are discussed in Section 3.3. This report focuses primarily on the dissolved phase of carbon tetrachloride in the upper portion of the aquifer (upper ~15 m). While carbon tetrachloride concentrations tend to be higher in the upper to middle portion of the aquifer, this is not always the case. There are a few wells that have shown the highest concentration at the bottom of the aquifer. The target for interim remediation during FY 2008 has been the upper portion of the aquifer, particularly those areas where carbon tetrachloride is greater than 2,000 µg/L (e.g., proximity of the cribs and trenches and west of the TX-TY Tank Farm). For the past seven years an extensive effort has been made to collect depth-discrete groundwater samples during well drilling to better define the three-dimensional distribution of contamination across

the operable unit. While these wells are most often completed to screen the interval showing the highest contaminant concentration, there are a few instances when wells are completed to screen other portions of the aquifer to support specific remediation strategies.

Significant features of the carbon tetrachloride plume in the upper part of the aquifer include the following.

- The extent of carbon tetrachloride at the drinking water standard (5 μg/L) (Figure 2.8-3) has increased in FY 2008. The 5 and 50 μg/L contour interval in the northeastern corner of 200 West Area has expanded downgradient to the northeast, based on increases in wells 299-W12-1 and 699-48-71, and side-gradient to the south.
- The FY 2008 concentrations of carbon tetrachloride in well 699-48-71 (located ~400 m north of the northeast corner of 200 West Area) continue to increase steadily in this region (Figure 2.8-4). The annual average carbon tetrachloride concentration increased from the FY 2007 concentration of 34 to 62 μg/L in FY 2008.
- The area of carbon tetrachloride at levels greater than 2,000 μg/L west of WMA TX-TY was steady. Well 299-W15-765 (screened through the upper 10.7 m of the aquifer) increased from the annual average concentration of 2,300 μg/L in FY 2007 to 2,800 μg/L in FY 2008. Well 299-W11-87 (located southeast of T Plant) increased from an annual average concentration of 1,700 μg/L in FY 2007 to 2,100 μg/L in FY 2008.
- The highest carbon tetrachloride concentration in FY 2008 for the 200 West Area was in extraction well 299-W15-44 (4,900 μg/L). Well 299-W15-44 is screened through the upper ~11 m of the aquifer and is located south-west of the WMA TX-TY.
- The highest annual average carbon tetrachloride concentration in FY 2008 for the 200 West Area was in extraction well 299-W15-34 (2,800 μg/L). Well 299-W15-34 is screened through the upper ~18 m of the aquifer. This value is up from an annual average concentration of 2,600 μg/L in FY 2007.

Figure 2.8-3 shows the extent of contamination near the upper part of the aquifer, but the three-dimensional extent is more complex. Drilling of new deep wells in the 200-ZP-1 groundwater interest area indicate in a few areas the highest carbon tetrachloride concentrations are found deeper in the aquifer. The FY 2007 Hanford Site Groundwater Monitoring (DOE/RL-2008-01) includes several cross-sections within the 200-ZP-1 Operable Unit that illustrate the vertical distribution of carbon tetrachloride in this area. Depth-discrete sampling during drilling in FY 2008 provides additional insight on the vertical distribution of carbon tetrachloride and is shown in Figure 2.8-5.

Depth-discrete groundwater samples were taken in three new wells (299-W11-88, 699-43-69, and 699-45-69C) completed in the 200-ZP-1 Operable Unit during FY 2008. Well 299-W11-88 (located ~1,100 m northeast of WMA T) was sampled during drilling and carbon tetrachloride concentrations ranged from 1,100 to 1,700 μg/L at depths of 4.24 to 28.34 m below the water table (87.81 m below ground surface [bgs]) (Figure 2.8-5). The well was completed with a screened interval of 135.63 to 147.82 m bgs, immediately above basalt. This interval does not monitor

the zone of elevated contaminants identified during the depth discrete sampling. The screened interval was specifically selected to monitor the lowest part of the aquifer above the basalt. The highest carbon tetrachloride in well 299-W11-88 after well completion was 9.9 μg/L. Well 699-43-69 (located ~700 m east of the 200 West Area) was sampled during drilling and carbon tetrachloride concentrations ranged from 140 to 240 μg/L at depths of 30.62 to 44.32 m below the water table (94.48 m bgs). The well was completed with a screened interval of 121.98 to 132.64 m bgs, immediately below the lower mud unit. This interval monitors the zone of elevated contaminants identified during the depth discrete sampling. The average carbon tetrachloride concentration after well completion was 220 μg/L. Well 699-45-69C (located ~700 m east of the 200 West Area) was sampled during drilling and carbon tetrachloride concentrations ranged from 15 to 22 μg/L at depths of 20.73 to 26.43 m below the water table (90.67 m bgs). The well was completed with a screened interval of 111.86 to 116.43 m bgs, immediately below the lower mud unit. This interval monitors the zone of elevated contaminants identified during the depth discrete sampling. The average carbon tetrachloride concentration after well completion was 23.5 μg/L.

### 2.8.1.2 Trichloroethene

*The trichloroethene plume in the 200-ZP-1 groundwater interest area was much smaller in FY 2008 than in FY 2007.*

Trichloroethene is detected at levels above the drinking water standard (5 μg/L) in the 200-ZP-1 groundwater interest area. The main trichloroethene plume extends north and northeast from the primary cribs and trenches, particularly the 216-Z-9 Trench. The size and configuration of the plume has decreased significantly since FY 2007 (Figure 2.8-6). Concentrations throughout the plume also are lower than in FY 2007. The most noticeable decline is in the southwestern portion of WMA T (e.g., well 299-W10-4). The maximum trichloroethene concentration was 14 μg/L during December 2008 in well 299-W15-44 (located near the southwest corner of WMA TX-TY). This well had an annual average trichloroethene concentration of 7.8 μg/L in FY 2008.

### 2.8.1.3 Chloroform

During FY 2008, the annual average chloroform concentrations in the 200-ZP-1 groundwater interest area remained below the 80 μg/L drinking water standard (defined for total trihalomethane). Concentrations are declining throughout the groundwater interest area. Possible chloroform sources include biodegradation of carbon tetrachloride and sanitary sewer discharges to the 2607-Z Tile Field. Chloroform also is found near WMAs TX-TY and T, as well as at depth below the water table to the northeast of these areas.

*Depth-discrete sampling in new wells 299-W11-88 and 299-W43-69 had elevated chloroform up to ~51 m below the water table.*

Depth-discrete sampling in new wells drilled during FY 2008 showed chloroform at depth in the aquifer. New well 299-W11-88 (located ~1,100 m northeast of WMA T) had the maximum concentration of chloroform (39 μg/L at ~110 m bgs) when sampled ~22.24 m below the water table (~87.81 m bgs). The well was completed with a screened interval of 135.63 to 147.82 m bgs. The well was completed immediately above basalt and does not monitor the zone of elevated contaminants identified during the depth discrete sampling. Well 299-W10-33 (completed near the bottom of the unconfined aquifer in September 2007) had a maximum chloroform concentration of 46 μg/L during depth discrete sampling. Concentrations in this well were below the detect limit (1.0 μg/L) during the February and August 2008.

### 2.8.1.4 Nitrate

Nitrate concentrations were above the drinking water standard (45 mg/L, as nitrate) beneath much of the 200-ZP-1 groundwater interest area (Figure 2.8-7). The maximum concentration in well 299-W10-4 (near the 216-T-36 Crib) decreased to 2,820 mg/L in FY 2008 from 3,810 mg/L in FY 2007. The annual average nitrate concentration in this well increased to 2,600 mg/L in FY 2008 from 2,464 mg/L in FY 2007. Multiple sources of nitrate probably exist in this area, including the cribs near WMA T and the primary cribs and trenches. Nitrate concentrations in well 299-W10-27 on the northeast corner of WMA TX-TY decreased in FY 2008.

*Nitrate concentrations in well 299-W10-27 on the northeast corner of Waste Management Area TX-TY decreased in FY 2008.*

Of the new wells, well 299-W11-88 had the highest nitrate concentration (274 mg/L) at a depth of 37.44 m below the water table (~87.81 m bgs) (Figure 2.8-8). The well was completed immediately above basalt and does not monitor the zone of elevated contaminants identified during the depth discrete sampling. During three sampling events in FY 2008, the average nitrate concentration was 67 mg/L in well 299-W11-88. Nitrate is found at depth below the water table because it was a co-contaminant with carbon tetrachloride when released to the soil column, and carbon tetrachloride is denser than water.

### 2.8.1.5 Chromium

Chromium contamination is found at levels above the drinking water standard (100 µg/L) at WMAs T and TX-TY (Figure 2.8-9). The hexavalent form of chromium is soluble and mobile in water. Figure 2.8-9 shows two areas of chromium contamination. One is a small area centered on well 299-W14-13, east of WMA TX-TY. In FY 2008, the maximum chromium concentration was in well 299-W14-13 at 640 µg/L. The annual average concentration declined from 660 µg/L in FY 2007 to 560 µg/L in FY 2008. The second area is larger and associated with WMA T and the adjacent past-practice disposal facilities. The highest annual average chromium concentration in well 299-W10-4 (located southwest of the WMA) declined from 475 µg/L (filtered) in FY 2007 to 420 µg/L in FY 2008. The chromium contamination at WMA T extends from well 299-W10-4 to the downgradient wells to the east, although there are no wells within the tank farm to ensure continuation of the plume. Sections 2.8.3.3 and 2.8.3.4 provide further information about chromium near WMAs T and WMA TX-TY, respectively.

*Well 299-W14-13 had the highest chromium results in the 200-ZP-1 Operable Unit at 640 µg/L.*

### 2.8.1.6 Fluoride

Fluoride contamination at levels greater than the primary drinking water standard (4 mg/L) historically has occurred in a local area around T Tank Farm. Well 299-W10-8 (located at the northwest corner of the tank farm) had the FY 2008 maximum fluoride concentration of 4.56 mg/L, and an annual average concentration of 4.36 mg/L. Release of lanthanum fluoride used in the bismuth phosphate process is a possible cause of this contamination.

### 2.8.1.7 Tritium

Tritium contamination at levels greater than the drinking water standard (20,000 pCi/L) in the 200-ZP-1 groundwater interest area is restricted mainly to a plume extending northeast from waste disposal facilities of WMAs T and TX-TY. These WMAs have multiple potential sources of tritium. In addition, tritium from permitted discharges at the State-Approved Land Disposal Site is found in the groundwater (Figure 2.8-10). Section 2.8.3.5 discusses tritium at the State-Approved Land Disposal Site.

During FY 2008, the tritium plume had the same general configuration as in FY 2007. Data downgradient to the northeast remains sparse because of a lack of wells in the area. The highest tritium concentrations in water-table wells remained at well 299-W14-13 (located east of WMA TX-TY), where the concentration in FY 2008 ranged from 270,000 to 1.2 million pCi/L. The annual average declined from 1.5 million pCi/L in FY 2007 to ~830,000 pCi/L in FY 2008. Well 299-W11-88 (located ~1,100 m northeast of WMA T) was sampled during drilling and had tritium concentrations from 5,180 to 1,410 pCi/L at depths of 4.3 to 28.4 m below the water table (~87.81 m bgs) (Figure 2.8-11). The well was completed immediately above basalt and does not monitor the zone of elevated contaminants identified during the depth discrete sampling. During FY 2008, tritium was not detected in routine samples from well 299-W11-88. Tritium levels in the 200-ZP-1 groundwater interest area continue on a downward trend in most wells in the network.

***The highest tritium concentration was in a well east of Waste Management Area TX-TY where concentrations averaged ~830,000 pCi/L.***

### 2.8.1.8 Iodine-129

Iodine-129 is found in the 200-ZP-1 groundwater interest area and has origins in the WMA TX-TY as (Figure 2.8-12). In FY 2008, the highest iodine-129 concentration (37.6 pCi/L) was in well 299-W14-13. The average annual concentration in this well declined from 38.3 pCi/L in FY 2007 to 31 pCi/L in FY 2008. Elevated iodine-129 also is found locally near WMA T (Section 2.8.3.3). Determining the extent of iodine-129 contamination is difficult because the detection limit is often near or above the 1.0 pCi/L drinking water standard.

### 2.8.1.9 Technetium-99

Technetium-99 within the 200-ZP-1 groundwater interest area is found at levels significantly above the drinking water standard (900 pCi/L) on the east (downgradient) side of WMA T and centered on two areas in the vicinity of WMA TX-TY (Figure 2.8-13). The maximum technetium-99 concentration (9,100 pCi/L) in FY 2008 was in well 299-W11-42 (located near the northeast corner of WMA T). The annual average concentration for the well was 7,500 pCi/L. Well 299-W11-88 (located ~1,100 m northeast of WMA T) was sampled during drilling and had technetium-99 concentrations between 130 and 260 pCi/L at a depth of 4.3 to 37.55 m below the water table (~87.81 m bgs) (Figure 2.8-14). The well was completed immediately above basalt and does not monitor the zone of elevated contaminants identified during the depth discrete sampling. During FY 2008, technetium-99 was undetected at 2.3 to 0.1 pCi/L in well 299-W11-88 after well completion. Well 299-W11-46 (located at the northeast corner of T Tank Farm) was converted to an extraction well in FY 2007 to mitigate technetium-99. The well is screened between 6.22 to 9.32 m below the water table (74.05 m bgs) and had an annual average technetium-99 concentration of 9,300 pCi/L in FY 2008. The maximum concentration in well 299-W11-46 was 18,000 pCi/L. This is down an order of magnitude from the FY 2007 annual average concentration of 97,000 pCi/L and maximum of 63,200 pCi/L. Sections 2.8.3.3 and 2.8.3.4 provide more information on technetium-99 contamination at WMAs T and TX-TY, respectively.

***Technetium-99 within the 200-ZP-1 Operable Unit is found above the drinking water standard (900 pCi/L) downgradient of Waste Management Areas T and TX-TY.***

***Only one well exceeded the drinking water standard (30 µg/L) for uranium in the 200-ZP-1 Operable Unit.***

### 2.8.1.10 Uranium

The highest uranium result during routine sampling in the 200-ZP-1 groundwater interest area was in well 299-W11-37 (located ~800 m northeast of WMA T). This well had a maximum concentration of 48.8 µg/L (unfiltered), and an annual average concentration of 48 µg/L (unfiltered) during FY 2008. Uranium levels have been

decreasing steadily since FY 2001. This is the only well to exceed the drinking water standard (30 μg/L) in the 200-ZP-1 groundwater interest area during FY 2008.

### 2.8.1.11 Other Constituents Monitored

Other constituents detected in groundwater at concentrations above the preliminary target action levels include antimony, arsenic, iron, and manganese. Methylene chloride and trichloroethene are monitored for the groundwater interest area as degradation products of carbon tetrachloride. Antimony concentrations in several wells at levels exceeded the drinking water standard (6 μg/L) in FY 2008. However, antimony results have been problematic. Detections are typically very close to the reported detection limit and are sporadic. Most detections preceding and during FY 2008 are believed to be false-positive results. Antimony from a filtered sample in well 299-W10-27 was reported as detected at 42.2 μg/L, but the unfiltered sample from the same event was below detection at 32.0 μg/L. A result of 36.6 μg/L also was reported in May 2008 in a filtered sample from well 299-W14-16, but all results before and since have been below detection.

During FY 2008, filtered arsenic was detected at levels above the 10 μg/L drinking water standard in only one well (299-W10-4) located southwest of WMA T. The maximum concentration was 10.8 μg/L. This concentration is slightly higher than the FY 2007 maximum of 10.3 μg/L. The Hanford Site filtered groundwater background for arsenic is 11.8 μg/L (95th percentile) (DOE/RL-96-61, *Hanford Site Background: Part 3, Groundwater Background*).

Iron was present at levels above the 300 μg/L secondary drinking water standard in eight groundwater monitoring wells and six wells during drilling in FY 2008. The maximum concentration in an unfiltered sample during routine sampling was 1,700 μg/L in well 299-W10-4. The filtered concentration was 20.0 μg/L. An unfiltered sample during drilling in well 299-W11-18 (located ~500 m northeast of WMA T) was 14,300 μg/L and the filtered sample was 124 μg/L. Both results are suspect. Iron is a naturally occurring component of the aquifer sediment and is found in well materials, particularly during drilling and corrosion after completion. Elevated iron levels in unfiltered samples from particulate material are possible. The background iron concentration for Hanford Site filtered groundwater is 55.3 μg/L (DOE/RL-96-61).

In FY 2008, manganese was detected at levels above the 50 μg/L secondary drinking water standard in filtered and unfiltered samples from several 200-ZP-1 groundwater interest area wells. The maximum concentration in FY 2008 was 309 μg/L for a filtered sample from well 299-W10-27 (located near the northeast corner of WMA TX-TY). The annual average was 270 μg/L in a filtered sample. Elevated manganese values in the first few years of sampling are common for newer wells at the Hanford Site, and are likely a reaction of groundwater with freshly crushed rock surfaces and corrosion of well materials. The elevated manganese levels in this well have persisted for ~7 years. The background manganese concentration for Hanford Site filtered groundwater is 2.2 μg/L (DOE/RL-96-61).

Methylene chloride was not detected at levels above the drinking water standard (5 μg/L) in the 200-ZP-1 groundwater interest area during FY 2008. The maximum concentration reported (3.7 μg/L) was from well 299-W15-36, located ~100 m east of the north end of the 216-Z-20 Crib. Methylene chloride (dichloromethane) can be a degradation product or impurity in carbon tetrachloride (tetrachloromethane), but is also a common laboratory contaminant.

Tetrachloroethene is often detected at levels below the drinking water standard (5 μg/L) in the 200-ZP-1 groundwater interest area. A total of six wells had detectable concentrations in FY 2008. The maximum concentration was 2.1 μg/L in wells 299-W10-4 (located near the southwest corner of WMA T) and 299-W10-24 (located near the northeast corner of WMA T).

## 2.8.2 Operable Unit Activities

***G. G. Kelty, Jr.***

Within the 200-ZP-1 Operable Unit, interim actions have been implemented for remediation of carbon tetrachloride, chloroform, and trichloroethene in the vicinity of the 216-Z Liquid Waste Disposal Units (primary cribs and trenches). The final remedy for the 200-ZP-1 Operable Unit will remediate carbon tetrachloride and seven other contaminants of concern throughout the vertical extent of the aquifer in accordance with EPA, 2008 signed in September 2008. Several reports (e.g., SGW-38923; DOE/RL-2008-02) provide the most recent update of the status of the remediation.

### 2.8.2.1 Status of Five-Year Review of Action Items

The second CERCLA five-year review was published in November 2006 (DOE/RL-2006-20). This document provided a comprehensive evaluation of the status of groundwater and source operable unit investigations and cleanup actions. All findings pertinent to the 200-ZP-1 Operable Unit for the 200 Area National Priority List (40 CFR 300, Appendix B) were completed in FY 2007.

### 2.8.2.2 CERCLA Investigations

DOE/RL-2003-55, *Remedial Investigation/Feasibility Study Work Plan for the 200-ZP-1 Groundwater Operable Unit*, was prepared in FY 2004 and implemented in FY 2005. The remediation investigation report (DOE/RL-2006-24, *Remedial Investigation Report for 200-ZP-1 Groundwater Operable Unit*) was published in October 2006. The feasibility study (DOE/RL-2007-28) and the proposed plan (DOE/RL-2007-33, *Proposed Plan for Remediation of 200-ZP-1 Groundwater Operable Unit*, were completed in July 2008. The final selected remedy for the 200-ZP-1 Operable Unit includes four components.

***A final remedy for the 200-ZP-1 Operable Unit was approved in FY 2008.***

- An extensive groundwater pump-and-treat system to capture and treat contaminated groundwater throughout the Operable Unit to reduce the mass of carbon tetrachloride and seven other contaminants of concern by a minimum of 95% in 25 years.
- In addition to the pump-and-treat system, natural attenuation processes will be used to reduce contaminant of concern concentrations to below cleanup levels in 125 years.
- Flow-path control will be achieved by injecting treated groundwater into the aquifer to the northeast and east of the contaminant plumes to slow the natural eastward flow of most of the groundwater. This will keep contaminants of concern within the capture zone of the pump-and-treat system, and increase the time available for natural attenuation processes to reduce the contaminant concentrations not captured by the extraction wells.
- Institutional controls will restrict 200-ZP-1 Operable Unit groundwater use for the foreseeable future until cleanup levels are achieved.

The selected remedy will be implemented in accordance with a remedial design/remedial action work plan being prepared in FY 2009.

### 2.8.2.3 Interim Action for Carbon Tetrachloride

The current pump-and-treat system is operating in the 200-ZP-1 Operable Unit to contain and capture the high concentration portion of the carbon tetrachloride plume within the upper portion of the aquifer south-west of the WMA TX-TY. The contaminants originating from discharges to the 216-Z-9, 216-Z-1A, and 216-Z-18 Cribs have migrated north and east of the waste sites. The 200-ZP-1 Pump-and-Treat System was implemented as an interim remedial measure in three phases, starting in 1996.

***The interim remedial action objectives for the 200-ZP-1 Operable Unit (EPA/ROD/R10 95/114) are as follows.***

- ***Reduce contamination in the area of highest concentration of carbon tetrachloride.***
- ***Prevent further movement of these contaminants from the highest concentration area.***
- ***Provide information that will lead to development of a final remedy that will protect human health and the environment.***

***The final feasibility study and proposed plan were issued in July 2008 (DOE/RL-2007-28; DOE/RL-2007-33). The final record of decision for the 200-ZP-1 Operable Unit was signed in September 2008 (EPA, 2008).***

The remedial action objectives for the pump-and-treat system are to capture the high concentration area of the carbon tetrachloride plume to reduce contaminant mass in the upper portion of the aquifer and to gather information to support remedial investigation/feasibility study decisions (EPA/ROD/R10-95/114, *Declaration of the Interim Record of Decision for the 200-ZP-1 Operable Unit*). The high concentration plume is defined by the 2,000 to 3,000 µg/L plume contour, which initially was centered beneath the Plutonium Finishing Plant and related waste sites. In 2005, concentrations of carbon tetrachloride exceeding the 2,000 µg/L remedial action goal were reported at wells west of the TX-TY Tank Farms. Four monitoring wells were converted to extraction wells and connected to the 200-ZP-1 Pump-and-Treat System. Pumping began in late July 2005 and is ongoing. A tenth well (299-W15-6) was added on September 28, 2006.

To increase treatment system capacity and capture of the high concentration portion of the plume, monitoring wells 299-W15-1, 299-W15-7, 299-W15-11, and 299-W15-46 were converted to extraction wells in FY 2008. Table 2.8-1 shows the major changes to the 200-ZP-1 Pump-and-Treat System. Figure 2.8-15 shows the carbon tetrachloride trends in these wells since FY 2000. The combined pumping rate of the network is ~1,400 L/min. In support of expansion activities, the 200-ZP-1 Pump-and-Treat System was shutdown in May 2008, and except for process and acceptance testing, remained offline until early September 2008.

Three new groundwater monitoring wells (299-W11-88, 699-43-69, and 699-45-69C) were installed in FY 2008 to obtain supplemental data to support the remedial investigation/feasibility study process. Wells 699-43-69 and 699-45-69C were drilled to bound the northeastern downgradient edge of the carbon tetrachloride plume and were screened below the lower mud unit. Both wells are ~700 m east of the eastern boundary of the 200 West Area. Well 299-W11-88, located ~1,100 m northeast of WMA T, was drilled to investigate carbon tetrachloride and uranium and was screened immediately above the basalt. A fourth well (299-W18-253) was installed in the overlying 200-PW-1 Operable Unit to support soil-vapor extraction activities (Section 3.3).

Carbon tetrachloride mass was reduced in the area of highest concentrations through pumping and treating over 304.5 million liters from ten groundwater extraction wells in FY 2008. This resulted in the removal of 461.5 kg of carbon tetrachloride in FY 2008. A recent modeling study indicates that 95% of the simulated carbon tetrachloride mass in the aquifer below the 200-ZP-1 Operable Unit fell between 56,308.5 kg and 111,141.9 kg (PNNL-18118, *Revised Geostatistical Analysis of the Inventory of Carbon Tetrachloride in the Unconfined Aquifer in the 200 West Area of the Hanford Site*). A total of 3.9 billion liters of water have been processed and 11,414.8 kg of carbon tetrachloride have been removed since startup in March 1994.

***Over 304.5 million liters of carbon tetrachloride contaminated groundwater were treated in FY 2008 and 461.5 kg of carbon tetrachloride were removed.***

Annual average carbon tetrachloride concentrations for FY 2008 ranged from 478 µg/L at extraction well 299-W15-36 to 2,800 µg/L at extraction well 299-W15-34. Annual average concentrations exceeded the 2,000 µg/L remedial action objective at extraction wells 299-W15-6, 299-W15-34, 299-W15-35, 299-W15-40, 299-W15-44, and 299-W15-765. Wells 299-W15-36, 299-W15-43, 299-W15-45, and 299-W15-47 had annual average carbon tetrachloride concentrations below the 2,000 µg/L remedial action objective. Figure2.8-16 shows the current concentrations of carbon tetrachloride in the vicinity of the 200-ZP-1 Pump-and-Treat System and Figure 2.8-17 shows carbon tetrachloride trends in selected wells with concentrations greater than 2,000 µg/L.

### 2.8.2.4 Ion Exchange Treatability Test

To alleviate the increasing technetium-99 concentrations in the 200-ZP-1 Pump-and-Treat System, an ion exchange treatability test was installed on extraction wells 299-W15-44 and 299-W15-765. The ion exchange system was started in late April 2007; however, a failed pipe connection delayed start of routine testing until July 2007. The system ran uninterrupted until it was shutdown in mid-December 2007.

Groundwater samples were collected from sampling ports twice per week and analyzed for technetium-99, carbon tetrachloride, nitrate, sulfate, chloride, alkalinity, and pH. The criteria for terminating the ion exchange treatability test was when 50% breakthrough of technetium-99 had been measured at the effluent of both of the resin test columns. The 50% breakthrough was the point at which the effluent concentration equaled one-half of the influent concentration. The data collected from the study were used to evaluate the effectiveness of the Purolite resin for selectively removing technetium-99 from groundwater.

***Ion exchange resin is an effective method to remove technetium-99.***

The results showed the following about the ion exchange resin:

- Adequately removes technetium-99 to below the drinking water standard
- Selectively removes technetium-99 over other anions (i.e., nitrate and sulfate) in solution
- Does not absorb carbon tetrachloride.

Breakthrough occurred approximately 6 to 7 months after the test began for the test columns on well 299-W15-44 and 299-W15-765. The tests were terminated with the EPA and DOE concurrence prior to meeting the 50% breakthrough endpoint because of cold weather complications. At the time of the test's termination, the test columns had attained 8% and 20% breakthrough on wells 299-W15-44 and 299-W15-765, respectively.

Overall, the results suggest that the ion exchange resin is an effective method to remove technetium-99 from the groundwater and will be considered in the final design of the 200-ZP-1 Pump-and-Treat System.

### 2.8.2.5 Pump-and-Treat Test System for Technetium-99

***Concentrations of carbon tetrachloride at all baseline plume wells have continued to remain stable or decline from previous years with only two wells routinely exceeding the 2,000 µg/L remedial action goal.***

A pump-and-treat test system began operating in September 2007 as part of a designed interim remediation activity to treat technetium-99 contamination, specifically to the east of and within WMA T. The interim remediation activity was implemented as part of the general remedial guidance for this Hanford Site operable unit, based on EPA/ROD/R10-95/114 and the data quality objectives process (WMP-28389, *T-Area Technetium-99 Data Quality Objectives Summary Report*). The pump-and-treat test system currently consists of two extraction wells (wells 299-W11-45 and 299-W11-46) that dispose of the extracted groundwater via a direct discharge-line connection to the 200 Area Liquid Effluent Retention Facility, and then to the Effluent Treatment Facility.

Extraction wells 299-W11-45 and 299-W11-46 operated sporadically in FY 2008 because of pump problems and scheduled Effluent Treatment Facility process and maintenance activities. Well 299-W11-45 operated ~135 days (the first two quarters of FY 2008) and discharged a total of 8.2 million liters, at an annual average pumping rate of 42 L/min. Well 299-W11-46 operated ~187 days (the first three quarters) and discharged a total of 36.2 million liters, at an annual average pumping rate of 134.4 L/min. This resulted in a total combined volume of 44.4 million liters of groundwater discharged to basin 43 at the Liquid Effluent Retention Facility and a total mass of 23.8 g of technetium-99 removed in FY 2008.

***Technetium-99 Test System Aquifer Test Results.*** Operation of the 200-ZP-1 Pump-and-Treat System induces both horizontal and vertical groundwater-flow components within the aquifer. An aquifer recovery test was conducted in FY 2008 to examine the hydrologic effects of the WMA T Pump-and-Treat Test System remediation activities within the underlying unconfined aquifer system. Ten WMA T wells were monitored during this investigation (299-W10-23, 299-W10-24, 299-W11-39, 299-W11-40, 299-W11-41, 299-W11-42, 299-W11-45, 299-W11-46, 299-W11-47, and 299-W11-48). The aquifer test analyzed water-level measurements for these monitoring wells during the shutdown and restart of the 200-ZP-1 Pump-and-Treat System from May to June of 2008.

Results showed interwell hydraulic property estimates for transmissivity ranged from 300 to 475 $m^2$/day, and hydraulic conductivity ranged from 6.11 to 9.69 m/d (geometric mean 8.01 m/d). Based on the investigation performed, the capture zone created by the pump-and-treat system has a significant effect on the area surrounding the remediation facility (i.e., 300 m for pumping durations of a month or more). These large-scale aquifer characterization results will be utilized for optimization and site selection of additional extraction wells within the WMA T Pump-and-Treat Test System.

### 2.8.2.6 Carbon Tetrachloride and Chloroform Attenuation Parameters

***J. S. Fruchter***

To support implementation of the final selected remedy for the carbon tetrachloride plume in the 200 West Area (EPA, 2008), more information is needed to assess the

fate and transport of the contamination. Parameters describing porosity, sorption, and chemical degradation have the largest influence on predicted plume behavior. Researchers from the Pacific Northwest National Laboratory are conducting a study of chemical degradation parameters under DOE's Environmental Management program. Results of this project will improve the ability to predict future movement of the plume. This effort will help define the pump-and-treat component of the final selected remedy and provide an estimate of where the plume would eventually stabilize in the absence of active remediation. During FY 2007 and FY 2008, long-term experiments involving contact of carbon tetrachloride or chloroform with sediment from the Hanford Site, or representative minerals, were initiated and sampled to determine the rates of chemical degradation across a range of temperatures. Because of the slow rates, some of experiments are expected to continue for five years.

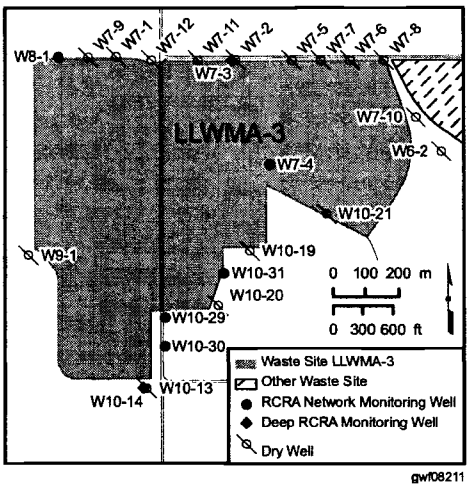
## 2.8.3 Facility Monitoring

### *D. G. Horton*

This section describes results of monitoring individual facilities (i.e., treatment, storage, or disposal units and tank farm WMAs T and TX-TY). Groundwater at some of these facilities is monitored under the requirements of RCRA for hazardous waste constituents and AEA for radionuclides, including source, special nuclear, and by-product materials. Data for facility-specific monitoring also are integrated into the CERCLA groundwater investigations. Groundwater data for these facilities are available in the Hanford Environmental Information System database and on the data files accompanying this report. Appendix B includes additional information, including well and constituent lists, maps, flow rates, and statistical tables. This section summarizes results of statistical comparisons, assessment studies, and other developments for FY 2008.

### 2.8.3.1 Low-Level Waste Management Area 3

Groundwater at Low-Level WMA 3 continued to be monitored under RCRA and AEA in FY 2008. Under 40 CFR 265.93(b) as referenced by WAC 173-303-400, the well network was sampled semiannually for RCRA indicator and site-specific parameters (PNNL-14859, *Interim Status Groundwater Monitoring Plan for Low-Level Waste management Areas 1 to 4, RCRA Facilities, Hanford Washington*). Appendix B includes a well location map and lists of wells and constituents monitored for the area. All seven wells in the network were sampled as scheduled during FY 2008, except well 299-W7-4. Well 299-W7-4 is located inside the WMA and was removed from the monitoring network in March 2008 because of safety concerns associated with cave-in potential.




The water table continued to decline beneath Low-Level WMA 3 during FY 2008 (~0.3 m/yr) in response to the greatly reduced discharge of wastewater to surface facilities around the 200 West Area. The groundwater flow in this portion of the 200 West Area is to the east-northeast based on the March 2008 water-level data (Figure 2.8-2). Assuming a water-table gradient of 0.0016 and a range in hydraulic conductivity values of 2.5 to 10 m/day (PNNL-14753, *Groundwater Data Package for the 2004 Composite Analysis*), the estimated flow rate at Low-Level WMA 3 is 0.04 to 0.16 m/day (Appendix B).

Wells 299-W10-19, 299-W10-20, and 299-W10-21 are now dry because of declines in the water table. Nitrate and carbon tetrachloride routinely exceeded drinking water standards in these wells. Carbon tetrachloride continued to exceed drinking water standards in three wells at Low-Level WMA 3 in FY 2008. Nitrate did not exceed the 45 mg/L drinking water standard in any well at the WMA in FY 2008.

Flow and monitoring data collected since RCRA monitoring was instituted in the 1980s indicate that carbon tetrachloride and nitrate are from plumes originating from sources to the south. Since then, changes in flow directions have left Low-Level WMA 3 with no monitoring wells on the upgradient (west) side. For this reason, statistical upgradient/downgradient comparisons have been suspended until background statistics can be re-established. Emplacement of new upgradient wells also has been postponed until the effects of the expanded pump-and-treat component of the final selected remedy (EPA, 2008) in the 200 West Area have been evaluated (Section 2.8.2.2). No suitable upgradient wells are available for use in the interim.

***Emplacement of new wells has been postponed until the effects of the proposed expanded pump-and-treat activities in the 200 West Area have been evaluated.***

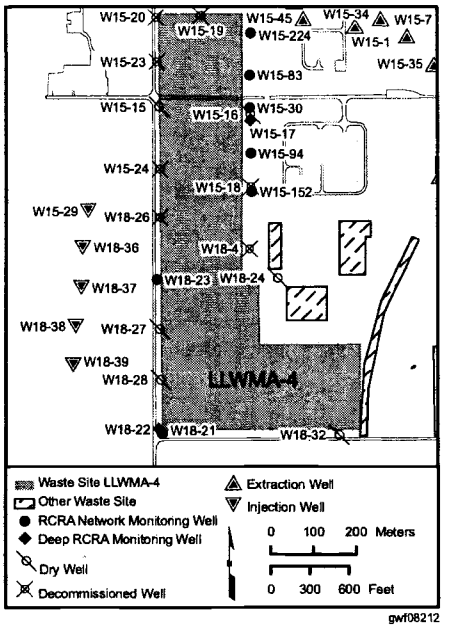
Performance assessment monitoring of radionuclides at Low-Level WMA 3 is designed to complement RCRA detection monitoring and is aimed specifically at monitoring radionuclide materials that are not regulated under RCRA. The current goal of performance assessment monitoring at Low-Level WMA 3 is to gather data to assess changes in concentrations at downgradient wells and to provide sufficient supporting information from upgradient wells to interpret the changes. Under the current monitoring plan (DOE/RL-2000-72, *Performance Assessment Monitoring Plan for the Hanford Site Low-Level Burial Grounds*), technetium-99, iodine-129, tritium, and uranium are monitored specifically for performance assessment.

Contaminants detected in groundwater at Low-Level WMA 3 include the following.

- Technetium-99 concentrations were all less than 20 pCi/L during FY 2008. Section 2.8.1.9 discusses the technetium-99 distribution in the 200-ZP-1 Operable Unit.
- Uranium concentrations at Low-Level WMA 3 were less than 2 μg/L (maximum 1.71 μg/L in well 299-W7-3) during FY 2008.
- Iodine-129 was not detected during FY 2008 and has not been detected in any wells currently in use at Low-Level WMA 3.
- Low-Levels of tritium were detected only in well, 299-W7-3 (28.9 pCi/L) in FY 2008.
- Carbon tetrachloride and associated trichloroethene and chloroform concentrations in Low-Level WMA 3 wells are consistent with those seen in regional plumes. Only carbon tetrachloride was detected at levels above the drinking water standard. The highest concentration was 150 μg/L in well 299-W10-31. Carbon tetrachloride concentrations in well 299-W10-31 show a decreasing trend since the well was drilled in FY 2006.
- The nitrate distribution at Low-Level WMA 3 is consistent with regional plumes (Section 2.8.1.4). The maximum concentration during FY 2008 (37.1 mg/L) was in well 299-W10-31.

### 2.8.3.2 Low-Level Waste Management Area 4

Groundwater at Low-Level WMA 4 is monitored under RCRA and AEA. Under 40 CFR 265.93(b) as referenced by WAC 173-303-400, the well network was sampled semiannually for RCRA indicator and site-specific parameters (PNNL-14859). Appendix B includes a well location map and lists of wells and constituents monitored for the area. New downgradient well locations had been identified and prioritized under the Tri-Party Agreement Milestone M-24, but the expected pump-and-treat component of the final selected remedy for the 200-ZP-1 Operable Unit has postponed the drilling of new wells in 200 West Area until the effects of the expanded pump-and-treat component are evaluated.




The groundwater flow in this portion of the 200 West Area is generally to the east, based on water-table contours. The flow direction is affected to a large degree by the 200-ZP-1 Pump-and-Treat System, which has extraction wells to the east and injection wells to the west of this RCRA site. The gradient is steeper and has a component to the northeast in the northern part of the area, and is somewhat less steep with a component to the southeast in the southern part of the area. The generalized flow direction, based on the March 2008 water table for the 200 West Area (Figure 2.8-2), was east-northeast in the northern portion of the facility, to slightly south of east in the southern portion. The hydraulic gradient is about 0.004. With a range in hydraulic conductivity values of 10 to 25 m/day, the estimated flow rate at Low-Level WMA 4 using these values is ~0.4 to 1.0 m/day (Appendix B). Two wells in the Low-Level WMA 4 monitoring network, upgradient wells 299-W15-15 and 299-W18-23, went dry during FY 2008.

***The general groundwater flow to the east at Low-Level Waste Management Area 4 is largely affected by injection wells to the west and extraction wells to the east.***

As in previous years, downgradient wells 299-W15-30, 299-W15-83, 299-W15-94, and 299-W15-224 continued to exceed the statistical comparison value for total organic halides in all samples during FY 2008. Well 299-W15-30 is a replacement for well 299-W15-16, which has gone dry. The DOE previously reported the exceedance of the statistical comparison value in well 299-W15-16 (now dry) to the EPA and Ecology in August 1999. The exceedances also have been iterated in annual groundwater reports. The elevated total organic halide concentrations are consistent with observed levels of carbon tetrachloride from Plutonium Finishing Plant operations (Sections 2.8.1.1 and 2.8.2) although more data are needed from the new wells to establish trends. Carbon tetrachloride concentrations display downward or level trends in all wells in the network for which historical data are available. During FY 2008, the maximum carbon tetrachloride concentration in well 299-W15-94 declined from 830 µg/L in FY 2007 to 310 µg/L in FY 2008. Known sources of carbon tetrachloride include the 216-Z-9 Trench, 216-Z-1A Tile Field, and 216-Z-18 Crib (DOE/RL-2006-20). Based on historical groundwater monitoring and interpretations of carbon tetrachloride plumes in the 200 West Area (e.g., DOE/RL-92-16, *200 West Groundwater Aggregate Area Management Study Report*), as well as the extensive source investigations in the 200 West Area (DOE/RL-2006-51, *Remedial Investigation Report for the Plutonium/Organic Rich Process Condensate/Process Waste Group Operable Unit: Includes the 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units*), these liquid waste disposal facilities were determined to be the principal sources of this contaminant in 200 West Area groundwater.

Total organic carbon exceeded the statistical comparison value in two wells (299-W15-30 and 299-W15-225) sampled in February 2008. A request for data review was submitted because the high total organic carbon concentration was much greater than historical concentrations. Both wells were resampled and the new results were less than the critical mean. Well 299-W15-224 exceeded the critical mean in August 2008. Again, requests for data review were submitted and samples submitted for reanalysis. Results from the reanalysis confirmed the exceedance and a groundwater quality assessment plan was written and submitted to Ecology. The other indicator parameters, pH and specific conductance did not exceed the comparison values for FY 2008. Appendix B lists statistical comparison values for use in FY 2009.

Performance assessment monitoring of radionuclides at Low-Level WMA 4 is designed to complement the RCRA detection monitoring. The current goal of performance assessment monitoring at Low-Level WMA 4 is to gather data to assess changes in concentrations at downgradient wells and to provide sufficient supporting information from upgradient wells to interpret the changes. Under the current monitoring plan (DOE/RL-2000-72), technetium-99, iodine-129, tritium, and uranium are monitored specifically for performance assessment.

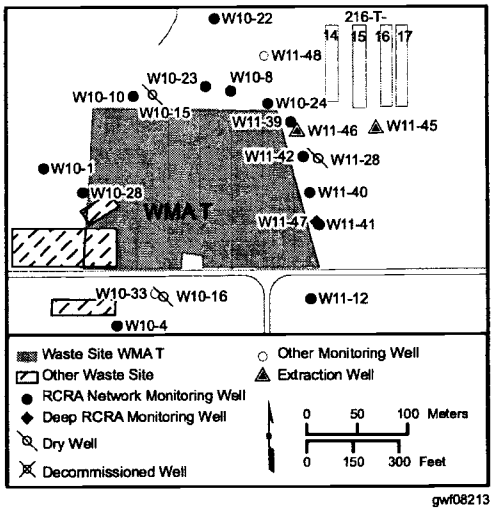
Contaminant characteristics at Low-Level WMA 4 include the following.

- In FY 2007, the technetium-99 concentrations increased in several wells on both the west (upgradient) and east (downgradient) sides of Low-Level WMA 4. Wells upgradient of WMA TX-TY containing high concentrations of technetium-99 were converted to extraction wells for the pump-and-treat system in mid-2005. The resulting increases in technetium-99 concentration in the injection water, coupled with a 20 to 25% increase in injection volume from the addition of new extraction wells, could have caused the increases in technetium-99 concentration in wells at Low-Level WMA 4 during FY 2007. A temporary extraction system for technetium-99 was applied to the extraction wells at WMA TX-TY in FY 2007 and was stopped near the end of FY 2007. The technetium-99 concentrations in wells at Low-Level WMA 4 increased only in well 299-W15-30 in FY 2008 (maximum concentration of 120 pCi/L). The technetium-99 concentrations in all other wells either decreased or remained steady. These decreases may be the result of extraction well operation in proximity to WMA TX-TY. However, other factors may have caused the recent fluctuations of technetium-99 concentrations at Low-Level WMA 4, because changes in technetium-99 at Low-Level WMA 4 appear fairly quickly after changes in the pump-and-treat system.
- The highest annual average uranium concentration in FY 2008 was 22 μg/L in upgradient well 299-W18-21, which is consistent with the FY 2007 concentration of 21 μg/L. In FY 2007, the uranium concentration was high in upgradient wells 299-W15-15 and 299-W18-23. The uranium concentration in well 299-W15-15 was 12.7 μg/L in FY 2007, but decreased to 7.7 μg/L at the end of FY 2007 before the well went dry. The FY 2007 average uranium concentration was 9.8 μg/L in well 299-W18-23, but decreased to 4.8 μg/L before going dry in mid FY 2008. The highest uranium concentration at downgradient locations was 3.20 μg/L in well 299-W15-152. This was a slight increase from 2.16 μg/L in FY 2007. These concentrations are consistent with regional concentrations.

- Iodine-129 was not detected in Low-Level WMA 4 wells during FY 2008.
- The highest tritium concentrations were 1,600 pCi/L in downgradient wells 299-W15-83 (1,900 pCi/L in FY 2007) and 299-W15-152 (1,400 pCi/L in FY 2007). The tritium concentration also increased from 1,000 pCi/L at the end of FY 2007 to 1,400 pCi/L at the end of FY 2008 in well 299-W15-30. The tritium concentration decreased during FY 2008 in upgradient well 299-W18-21 from 1,430 pCi/L to 900 pCi/L. The tritium concentration remained steady in all other wells during FY 2008. Tritium concentrations at Low-Level WMA 4 are consistent with regional concentrations.
- Nitrate continued to exceed the drinking water standard at all monitoring wells in Low-Level WMA 4, except downgradient well 299-W15-17 (27 mg/L) and deep well 299-W18-22 (19 mg/L). The maximum concentration in FY 2008 was in upgradient well 299-W18-23 (141 mg/L), before the well went dry in mid FY 2008. The highest nitrate concentration in all other downgradient wells was between 104 and 129 mg/L and trends remained steady. Nitrate contamination is likely unrelated to waste disposal at the burial grounds. Some of the nitrate contamination is related to injection of treated water upgradient of the burial ground. The treatment system does not remove nitrate from the water.
- Concentrations of carbon tetrachloride, trichloroethene, and chloroform are consistent with regional plumes (Sections 2.8.1.1, 2.8.1.2, and 2.8.1.3). In FY 2008, the maximum concentration of carbon tetrachloride was in well 299-W15-94 (310 μg/L). All wells in the network with results above detection show steady or decreasing trends. Chloroform and trichloroethene concentrations remained below the drinking water standard. No wells had trichloroethene concentrations above detection limits.

### 2.8.3.3 Waste Management Area T

WMA T is located in the north-central part of the 200 West Area and consists of the T Tank Farm with its ancillary equipment (e.g., diversion boxes and pipelines). The tank farm contains twelve 2-million-liter tanks and four 208,000-liter tanks constructed between 1943 and 1944. Seven of the tanks in the WMA are known or suspected to have leaked (RPP-23405, *Tank Farm Vadose Zone Contamination Volume Estimates*). This section describes groundwater monitoring at WMA T. Appendix B includes a well location map and lists of wells and constituents monitored for the area.




***Chromium and nitrate are found in groundwater near Waste Management Area T.***

The objective of RCRA groundwater monitoring at WMA T is to assess the extent and rate of movement of dangerous wastes in groundwater that have a source from the WMA (40 CFR 265.93(d) as referenced by WAC 173-303-400). PNNL-15301, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area,* documents the groundwater assessment plan for WMA T. In addition to monitoring dangerous waste constituents for RCRA assessment, the site is monitored under CERCLA and AEA. WMA T originally was placed in RCRA assessment monitoring because of elevated specific conductance in downgradient well 299-W10-15 (WHC-SD-EN-AP-132, *Interim-Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Areas T and TX-TY*). This area remains in assessment because of continued elevated contaminants observed in downgradient wells.

Dangerous waste constituents found in groundwater near WMA T in FY 2008 are chromium and nitrate. These constituents probably originate from more than one source, including the WMA. Other constituents found near the WMA in FY 2008 include carbon tetrachloride, trichloroethene, fluoride, tritium, and technetium-99. The carbon tetrachloride and trichloroethene do not appear to be from WMA T (Sections 2.8.1.1 and 2.8.1.2). Tritium is believed to be part of a regional plume, although a contribution from WMA T cannot be disregarded. The technetium-99 plume, located east (downgradient) of the T Tank Farm, is attributed in part to the tank farm.

***In September 2007, downgradient wells 299-W11-45 and 299-W11-46 were converted to extraction wells to remove technetium-99 from the aquifer east of Waste Management Area T.***

In September 2007, downgradient wells 299-W11-45 and 299-W11-46 were converted to extraction wells to remove technetium-99 from groundwater. Extraction of groundwater from the downgradient wells has altered the flow regime. Figure 2.8-18 shows the water-table elevation in several wells at WMA T. The figure shows drawdown in wells around the WMA after extraction began in wells 299-W11-45 and 299-W11-46 and the degree of drawdown increases as the distance between the extraction wells and the measured wells decreases. Prior to the start of extraction, calculated average linear groundwater flow velocities at WMA T ranged from 0.002 to 0.25 m/day, with most values less than 0.1 m/day. The groundwater flow direction beneath the WMA was to the east between 85 and 98° from the north, as determined by trend surface analyses (PNNL-13378; PNNL-14113). Since the initiation of the technetium-99 pump-and-treat, the groundwater flow velocity is closer 0.02 to 0.56 m/day based on the most recent water-table map. The recent groundwater extraction at WMA T has caused slight deviations from prior flow conditions. Figure 2.8-2 is the most current water-table map.

The monitoring network for WMA T includes fourteen wells that are sampled quarterly and two wells sampled semiannually. With a few exceptions, all samples were collected as scheduled in FY 2008. Sampling of well 299-W11-7 was unsuccessful in November and December 2007 because of a broken valve. Upgrades at the Effluent Treatment Facility prevented August 2008 samples from being collected from extraction wells 299-W11-45 and 299-W11-46 because the extraction system was shut down. The Effluent Treatment Facility was back online in November 2008.

***An aquifer recovery test was undertaken to examine the effects of the 200-ZP-1 Pump-and-Treat System on the vertical and horizontal flow components within the unconfined aquifer system.***

Extraction well 299-W11-45 was shut down on March 6 and restarted on July 7, 2008 and extraction well 299-W11-46 was shut down on May 1 and restarted on June 4, 2008 to perform an aquifer recovery test. Water-table recovery (and drawdown after the extraction wells were restarted) was monitored in eight additional wells at the WMA. The May sampling event at WMA T was postponed in the wells used for the aquifer test until July 2008 to allow uninterrupted completion of the test.

Figure 2.8-9 shows a plume map of FY 2008 annual average chromium concentration in wells in the uppermost part of the aquifer near the WMA T. The map shows that the chromium plume extends from the western and southwestern part of the WMA to northeast of the WMA. The highest annual average chromium concentration in the upper part of the aquifer during FY 2008 was in well 299-W10-4 (420 µg/L filtered and 540 µg/L unfiltered) located at the southwestern corner of the WMA. The chromium concentration in upgradient well 299-W10-28, which had been above the drinking water standard in 2003 through 2006, decreased to an annual average concentration of 65 µg/L (filtered) or 70 µg/L (unfiltered) in FY 2007. Although the annual average chromium concentration in FY 2008 decreased from FY 2007, the

concentration at the end of FY 2008 was 121 µg/L (filtered) compared to 95 µg/L (filtered) at the end of FY 2007. The chromium concentration in the upper part of the aquifer also exceeded the drinking water standard in three downgradient wells where the concentration ranged from 95 to 195 µg/L (filtered) and 100 to 195 µg/L (unfiltered). The chromium concentration increased in some wells and decreased in others. Interpreting the chromium concentration changes is complicated by the intermittent operation of extraction wells in the area.

The highest annual average chromium concentration found in wells screened at a depth below the water table in WMA T was 145 µg/L (both filtered and unfiltered) in wells 299-W11-45 and 299-W11-47. The annual average chromium concentration in well 299-W11-46, screened between 6 and 12 m below the water table, was 115 µg/L (filtered) and 120 µg/L (unfiltered). The annual average chromium concentration in adjacent well 299-W11-39 (screened at the water table) was 60 µg/L (filtered) and 55 µg/L (unfiltered). The higher concentrations in the deeper screened wells show that the chromium plume at WMA T extends relatively deep in the aquifer downgradient of the WMA.

***The highest average chromium concentration found at Waste Management Area T was 420 µg/L (filtered) or 540 µg/L (unfiltered) in well 299-W10-4.***

A fluoride plume was present north and east of WMA T in FY 2008. The annual average fluoride concentration exceeded the 4.0 mg/L primary drinking water standard in two wells located north of the WMA: well 299-W10-8 (4.36 mg/L) and well 299-W10-23 (4.32 mg/L). These wells have a history of high fluoride concentrations. The annual average fluoride concentration also exceeded the secondary drinking water standard (2.0 mg/L) in eight wells at the WMA, two of which had a reported concentration exceeding the primary drinking water standard in FY 2008 (299-W11-46 and 299-W10-24).

A local nitrate plume is located within the regional nitrate plume and beneath WMA T (Figure 2.8-7). The plume retains the same general configuration as in FY 2007. The highest annual average nitrate concentrations were in upgradient wells 299-W10-28 (1,068 mg/L) and 299-W10-4 (2,566 mg/L). The highest nitrate concentrations in downgradient wells were between 63 and 761 mg/L. More than one source, including the WMA T, probably contributed to the nitrate plume beneath the WMA, but the higher upgradient concentrations indicate greater contributions from other sources. Section 2.8.1.4 discusses nitrate contamination in the north central part of 200 West Area.

***The highest average nitrate concentrations were in upgradient well 299-W10-28 (1,068 mg/L) and well 299-W10-4 (2,566 mg/L).***

Tritium exceeded the interim drinking water standard (20,000 pCi/L) in one well at WMA T. In FY 2008, the annual average tritium concentration in well 299-W11-12 (located at the southeast corner of the WMA) was 38,000 pCi/L. This is a decrease from 44,000 pCi/L during FY 2007. The tritium concentration has been slowly decreasing in this well since 1998. The source of the tritium is thought to be farther south near the TX and TY Tank Farms, as shown in Figure 2.8-10.

A technetium-99 plume is located along the east (downgradient) side of WMA T (Figure 2.8-13). The maximum technetium-99 concentrations in the upper part of the aquifer are in downgradient well 299-W11-42. The annual average technetium-99 concentration for well 299-W11-42 increased from 1,715 pCi/L in FY 2007 to 7,460 pCi/L in FY 2008. The annual average technetium-99 concentration also increased in downgradient well 299-W11-40 from 1,845 pCi/L in FY 2007 to 6,740 pCi/L in FY 2008. In all other downgradient wells at WMA T, however, the technetium-99 concentration decreased during FY 2008 (Figure 2.8-19).

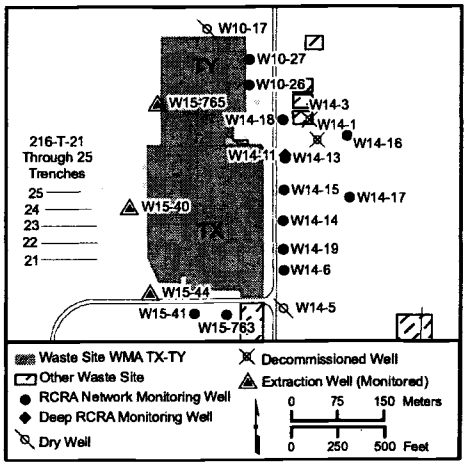
***The technetium-99 concentration decreased dramatically throughout the year in well 299-W11-46 after groundwater extraction began for technetium-99 remediation.***

Figure 2.8-20 shows the technetium-99 concentration in downgradient wells that are screened at depth below the water tables. The technetium-99 concentration decreased in all wells screened deeper in the aquifer in FY 2008. All downgradient wells were affected by the extraction in FY 2008 and the large changes in technetium-99 concentrations are most likely a result of the extraction.

Iodine-129 exceeded the drinking water standard (1 pCi/L) during the first quarter of FY 2008 in well 299-W11-45 (2.76 pCi/L) and well 299-W11-46 (3.23 pCi/L). Iodine-129 was not detected in subsequent samples from either well. Both wells are screened at depth below the water table downgradient of WMA T.

Antimony was reported in several samples near the detection limit during the year. The reported concentrations were the result of problems in the laboratory and were not representative of groundwater (Appendix C).

### 2.8.3.4 Waste Management Area TX-TY




WMA TX-TY is located in the north-central part of the 200 West Area and consists of the TX and TY Tank Farms and ancillary equipment (e.g., diversion boxes and pipelines). The tank farms contain twenty-four 2.9-million-liter tanks constructed between 1944 and 1952. Twelve of the tanks in the WMA are known or suspected to have leaked. Appendix B includes a well location map and lists of wells and constituents monitored for the area.

WMA TX-TY was originally placed in RCRA assessment monitoring (40 CFR 265.93(d) as referenced by WAC 173-303-400) because of elevated specific conductance in downgradient wells 299-W10-27 and 299-W14-12 (WHC-SD-EN-AP-132). The groundwater assessment plan for WMA TX-TY was updated in FY 2007 (PNNL-16005, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area TX-TY*) to incorporate information obtained from new wells drilled since the most recent interim change notice to the previous plan (PNNL-12072-ICN-1, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area TX-TY at the Hanford Site, Interim Change Notice 1*). The objective of RCRA groundwater monitoring at WMA TX-TY is to assess the concentrations, extent, and rate of movement of dangerous waste in groundwater that have a source from the WMA, as specified in 40 CFR 265.94(a)(2)(ii)(2)(d)(4). In addition to monitoring dangerous waste constituents for RCRA assessments, the site is monitored under AEA and CERCLA.

***Twelve of the tanks in Waste Management Area TX-TY are known or suspected to have leaked.***

The monitoring network for WMA TX-TY includes 16 wells that are sampled quarterly. All upgradient wells for the WMA were converted to extraction wells for the 200-ZP-1 Pump-and-Treat System in July 2005. All wells were sampled as scheduled during FY 2008, except upgradient wells 299-W15-40, 299-W15-44, and 299-W15-765 that could not be sampled because the 200-ZP-1 Pump-and-Treat System was offline for maintenance and upgrades, and well 299-W15-763 because of a sampling error.

Groundwater flow direction varies beneath the WMA because of influences from the pump-and-treat operation. In the northern part of the WMA, groundwater flow is changing from eastward to westward because of the recently converted extraction wells, as indicated by the arrival of technetium-99 at the wells soon after extraction

began. South of WMA TX-TY, groundwater flow direction is toward extraction wells located south or southwest of the WMA.

Dangerous waste constituents found in groundwater near WMA TX-TY in FY 2008 are chromium and nitrate. Other constituents found near the WMA in FY 2008 include carbon tetrachloride, trichloroethene, tritium, technetium-99, and iodine-129. The carbon tetrachloride and trichloroethene are attributed to Plutonium Finishing Plant operations (Sections 2.8.1.1 and 2.8.1.2).

***Dangerous waste constituents found beneath Waste Management Area TX-TY in FY 2008 are chromium and nitrate.***

In FY 2008, nitrate concentrations exceeded the drinking water standard (45 mg/L) in all wells in the WMA TX-TY monitoring network. Figure 2.8-7 shows a plume map for nitrate in the area. Overall, the nitrate concentrations remain steady in most wells at the WMA.

The highest annual average nitrate concentration at the WMA during FY 2008 was 695 mg/L in downgradient well 299-W10-27, a decrease from 720 mg/L in FY 2007. The annual average nitrate concentration in other downgradient wells was between 65 and 353 mg/L. The nitrate concentration in most wells remained consistent with FY 2007 concentrations.

Much of the nitrate contamination at WMA TX-TY is attributed to Plutonium Finishing Plant operations, as well as past-practice disposal to cribs and trenches in the area. Some nitrate contamination also may be from WMA TX-TY, although distinguishing the different sources is difficult. Section 2.8.1.4 provides information on nitrate in north-central 200 West Area.

***Much of the nitrate contamination at Waste Management Area TX-TY is attributed to Plutonium Finishing Plant operations, as well as past-practice disposal to cribs and trenches in the area.***

In FY 2008, chromium was detected above the drinking water standard (100 µg/L) in two wells shown in Figure 2.8-9 and in well 299-W14-11 (completed deeper in the aquifer). The highest annual average chromium concentration was 580 µg/L (unfiltered) and 564 µg/L (filtered) in downgradient well 299-W14-13. This was a decrease from 660 µg/L (filtered) during FY 2007. The chromium concentration has been elevated in this well since it was drilled in 1998 and was elevated in the early 1990s in adjacent but now dry well 299-W14-12. The chromium contamination in the area is accompanied by elevated concentrations of nitrate, iodine-129, technetium-99, and tritium.

Well 299-W14-11 is located next to well 299-W14-13, but is screened between 11.6 and 14.6 m below the water table. The annual average chromium concentration in well 299-W13-11 was 228 µg/L (unfiltered) and 232 µg/L (filtered). This is substantially higher than the annual average of 76 µg/L (filtered) during FY 2007. This indicates that significant chromium may exist deeper in the aquifer than shown by wells screened at the water table, although the highest concentrations appear to be near the water table in the area. The source for the chromium is assumed to be WMA TX-TY because no alternative sources have been identified.

***The chromium contamination in the area is accompanied by elevated concentrations of nitrate, iodine-129, technetium-99, and tritium.***

In FY 2008, well 299-W14-15 is located south of well 299-W14-13. The annual average chromium concentration in the well was 112 µg/L (unfiltered) and 109 µg/L (filtered). This is the first time that the chromium concentration has been above the drinking water standard in this well. However, the chromium concentration decreased throughout the year from 177 µg/L in November 2007 to 68 µg/L in August 2008 (Figure 2.8-21). The chromium concentration began a dramatic increase in mid-FY 2007, peaked at the beginning of FY 2008, and has decreased since that time. Nitrate, technetium-99, iodine-129, and tritium accompanied chromium, and all five contaminants show the same trend (Figures 2.8-21 and 2.8-22). This indicates that

all five contaminants share a common plume and that the plume passed through the well in a short period of time at the end of FY 2007 and beginning of FY 2008.

A small tritium plume exists along the east-central part of WMA TX-TY (Figure 2.8-10). The tritium concentration exceeded the drinking water standard (20,000 pCi/L) in three wells in the area. The highest FY 2008 average tritium concentration was 830,000 pCi/L in well 299-W14-13, a decrease from 1.5 million pCi/L in FY 2007. The tritium concentration generally has been decreasing since November 2006 when the concentration was 1.76 million pCi/L. However, the decrease accelerated in FY 2008 from 1.2 million pCi/L in November 2007 to 270,000 pCi/L in August 2008. The annual average tritium concentration in adjacent well 299-W14-11 (screened from 11.6 to 14.6 m below the water table) increased from 127,400 pCi/L in FY 2007 to 457,500 pCi/L in FY 2008. The tritium concentrations in these two wells indicate that the highest concentrations are near the water table in this area.

The tritium concentrations in well 299-W14-15 (located south of well 299-W14-13) also exceeded the drinking water standard during FY 2008 with an annual average concentration of 131,000 pCi/L. Although the annual average tritium concentration increased from 97,000 pCi/L in FY 2007, the concentration dropped throughout FY 2008 to 81,000 pCi/L in August 2008 (Figure 2.8-22). The source for the high tritium in the area could be WMA TX-TY, the 242-T Evaporator, the 216-T-19 Crib and Tile Field (which received evaporator condensate from the 242-T Evaporator), the 216-T-26 through 216-T-28 Cribs, or a combination of these potential sources.

***The highest concentrations of technetium-99 and other contaminants east of WMA TX-TY are found near the water table.***

In FY 2008, technetium-99 exceeded the interim drinking water standard (900 pCi/L) in wells 299-W14-11 and 299-W14-13 at WMA TX-TY. The annual average technetium-99 concentration decreased in well 299-W14-13 from 6,700 pCi/L in FY 2007 to 6,000 pCi/L in FY 2008, but increased in deeper well 299-W14-11 from 2,325 to 4,350 pCi/L. The data from these two wells indicate that the highest technetium-99 concentrations are near the water table in that area, similar to chromium, nitrate, iodine-129, and tritium.

The technetium-99 concentration also exceeded the drinking water standard in two other downgradient wells at WMA TX-TY. The annual average concentration in well 299-W14-15 (south of the wells 299-W14-11 and 299-W14-13) was 1,650 pCi/L during the year, similar to 1,700 pCi/L during FY 2007. The annual average technetium-99 concentration was 1,278 pCi/L in well 299-W10-26. This is the first time that the annual average technetium-99 concentration has exceeded the drinking water standard in this well. The source for the technetium-99 in these wells east of the WMA could be the WMA, one of the past-practice disposal facilities in the area, or both.

Technetium-99 also is above the drinking water standard in wells south and west of the WMA (Figure 2.8-13). Technetium-99 in these wells is likely drawn to the wells from beneath the TX and TY Tank Farms by extraction for the 200-ZP-1 Pump-and-Treat System. Wells 299-W15-44 and 299-W15-765 began operation as extraction wells for the 200-ZP-1 Operable Unit in July 2005 and the technetium concentrations began to increase in these wells shortly thereafter.

Iodine-129 exceeded the 1 pCi/L drinking water standard in three wells at WMA TX-TY during FY 2008 (Figure 2.8-12). The highest iodine-129 concentration measured at the WMA during the reporting period was 37.6 pCi/L in the May 2008 sample from well 299-W14-13. The annual average iodine-129 concentration declined

in the well from 38.3 in FY 2007 to 31 pCi/L in FY 2008. The annual average iodine-129 concentration in adjacent and deeper screened well 299-W14-11 increased from 4.8 pCi/L in FY 2007 to 15.8 pCi/L in FY 2008. Although the difference in iodine-129 concentration between the two wells is less than in the past, the data continue to indicate that the highest iodine-129 contamination resides near the water table, similar to the other contaminants in the area.

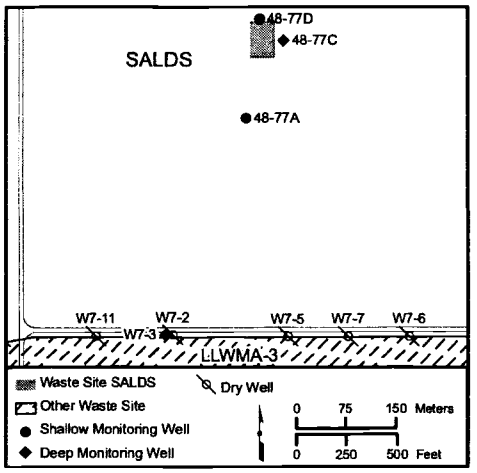
Iodine-129 also was detected in well 299-W14-15, located south of well 299-W14-13. The iodine-129 concentration in this well decreased throughout the year from 8.95 pCi/L in November 2007 to 3.92 pCi/L in August 2008 (Figure 2.8-21).

Manganese exceeded the secondary drinking water standard of 50 µg/L in well 299-W10-27 where the annual average FY 2008 concentration was 270 µg/L (filtered) and 266 µg/L (unfiltered). The manganese concentration has been high in this well since it was first sampled in 2001, although the concentration has decreased dramatically since that time. It is common for new wells on the Hanford Site to have elevated manganese concentrations during the first few years of sampling, but the elevated manganese in this well has persisted. The reason for the elevated manganese is unknown.

Nickel-63 was found in well 299-W14-11 in November 2007 (122 pCi/L) and in well 299-W14-13 in November 2007 (450 pCi/L) and May 2008 (688 pCi/L). One-twenty-fifth of the derived concentration guide (equivalent to 4 mrem or the drinking water standard for gross beta) for nickel-63 is 12,000 pCi/L, larger than the detected concentrations at the WMA.

### 2.8.3.5 State-Approved Land Disposal Site

The Hanford Site 200 Area Effluent Treatment Facility processes contaminated aqueous waste from Hanford Site facilities. The treated wastewater occasionally contains tritium, which is not removed by the Effluent Treatment Facility, and is discharged to the 200 Area State-Approved Land Disposal Site (SALDS). The SALDS operates on a fiscal year of September 1 to August 30, not the October 1 to September 30 observed by the DOE. During the first 11 months of FY 2008, 75.15 million liters of water were discharged to the SALDS, compared to 13.9 million liters in FY 2007. The expansion of the pump-and-treat systems on the Hanford Site is largely responsible for this increased volume.




A state waste discharge permit (WAC 173-216) requires groundwater monitoring at this site. The permit was granted in June 1995 and the site began operations in December 1995. Groundwater monitoring requirements are described in the site-monitoring plan (PNNL-13121, *Groundwater Monitoring and Tritium Tracking Plan for the 200 Area State- Approved Land Disposal Site*). Groundwater monitoring for tritium was conducted in 12 wells around the facility (Appendix B). The permit stipulates requirements for groundwater monitoring and establishes enforcement limits for concentrations of 15 constituents in three additional wells immediately surrounding the facility (Appendix B).

***During FY 2008, 75.15 million liters of water were discharged to the State-Approved Land Disposal Site.***

Wells immediately surrounding the facility were sampled four times in FY 2008. Tritium tracking wells were sampled semiannually. Many of the wells in the tritium-tracking network south of the SALDS have gone dry. Water-level measurements in the three wells nearest the SALDS indicated a small, localized groundwater mound centered on well 699-48-77A, a result of discharges from treating

groundwater from extraction wells at the 200-UP-1 Operable Unit and WMA T in the 200-ZP-1 Operable Unit. This mound results in radial flow outward a short distance before the regional northeastward flow predominates. This condition also places several wells south of the SALDS hydraulically downgradient of the facility.

Maximum tritium activities increased by an order of magnitude at well 699-48-77A (820,000 pCi/L), but remained unchanged in the other two proximal wells, 699-48-77C (68,000 pCi/L) and 699-48-77D (120,000 pCi/L). The tritium concentration in well 699-48-77A was the peak concentration for this well in a decade (Figure 2.8-23). This is likely because of several intermittent Effluent Treatment Facility campaigns in FY 2006 and FY 2007 to treat K Basin wastewater.

Concentrations of all chemical constituents with permit limits were within those limits or below detection limits during all of FY 2008. Acetone, benzene, cadmium, chloroform, and tetrahydrofuran were below method detection limits in all samples. Three target metals were found at or near-detection concentrations in well 699-48-77A. Concentrations of lead, copper, and mercury were present at 1.58 µg/L, 0.628 µg/L, and less than detection, respectively. Concentrations of major anions and cations continued at below-background levels observed prior to operation of the facility. The low concentrations are because of dilution by the otherwise clean water discharged to the SALDS.

For all wells, the hydraulic head in March 2008 had declined an average of 0.09 m/yr since March 2007. This average rate of decline includes increasing water levels at the three proximal wells at the SALDS area between March 2007 and March 2008. A less-biased rate of decline can be calculated if water-level changes in the proximal wells are excluded. This calculation shows that the FY 2008 average rate of decline of the water level in the area is 0.26 m/yr, which is consistent to the average calculated for FY 2007 (0.27 m/yr). Numerical flow-and-transport modeling of the SALDS was last conducted in August 2004, as required by the permit (PNNL-14898, *Results of Groundwater Modeling for Tritium Tracking at the Hanford Site 200 Area State-Approved Land Disposal Site – 2004*).

***Groundwater monitoring in the 200-ZP-1 groundwater interest area includes the following monitoring activities.***

***CERCLA Monitoring (Appendix A)***

- ***Seventy-three wells are scheduled for quarterly to biennial sampling. In FY 2008, five wells were not sampled and 18 other wells were sampled less frequently than planned.***
- ***The DOE installed and began to sample three new groundwater wells in FY 2008.***

***Facility Monitoring (Appendix B)***

- ***Seven wells are scheduled for semiannual sampling for Low-Level Waste Management Area 3. One well was sampled less frequently than planned in FY 2008.***
- ***Ten wells are scheduled for semiannual sampling for Low-Level Waste Management Area 4. Two of the wells went dry in FY 2008.***
- ***Sixteen wells are scheduled for quarterly to semiannual sampling for Waste Management Area T. The wells were sampled as planned.***
- ***Sixteen wells are scheduled for quarterly to semiannual sampling for Waste Management Area TX-TY. One quarterly sample was missed for four wells.***
- ***Twelve wells are scheduled for quarterly to semiannual sampling for the State-Approved Land Disposal Site. All were sampled as planned.***

**Table 2.8-1. Major Changes to the 200-ZP-1 Pump-and-Treat System.**

| Time Period | Activities |
|---|---|
| 1994 through 1995 | Conducted Phase I operations using one extraction well (299-W18-1) and one injection well (299-W18-4). |
| 1996 through 1997 | Conducted Phase II operations using three extraction wells (299-W15-33, 299-W15-34, and 299-W15-35) and a single injection well (299-W15-29). Phase I wells 299-W18-1 (extraction) and 299-W18-4 (injection) were converted to monitoring wells. |
| 1997 through 2001 | Conducted Phase III operations. Operations started using the existing three wells, plus three more recent wells (299-W15-32, 299-W15-36, and 299-W15-37) and five injection wells (299-W15-29, 299-W18-36, 299-W18-37, 299-W18-38, and 299-W18-39). |
| 2001 | Well 299-W15-37 was converted to a monitoring well, reducing the number of extraction wells to five. |
| 2004 | Wells 299-W15-45 and 299-W15-47 were brought on-line to replace extraction wells 299-W15-32 and 299-W15-33. |
| 2005 | Wells 299-W15-40, 299-W15-43, 299-W15-44, and 299-W15-765 were converted to extraction wells, bringing the number of extraction wells to nine. |
| 2006 | Well 299-W15-6 was converted from an out-of-service monitoring well to an extraction well, bringing the number of extraction wells to 10. |
| 2008 | Monitoring wells 299-W15-1, 299-W15-7, 299-W15-11, and 299-W15-46 were converted to extraction wells, bringing the number of extraction wells to 14. |
| All of the extraction wells are completed in the upper portion of the aquifer. | |

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**Figure 2.8-1. Facilities and Groundwater Monitoring Wells in the 200 West Area.**

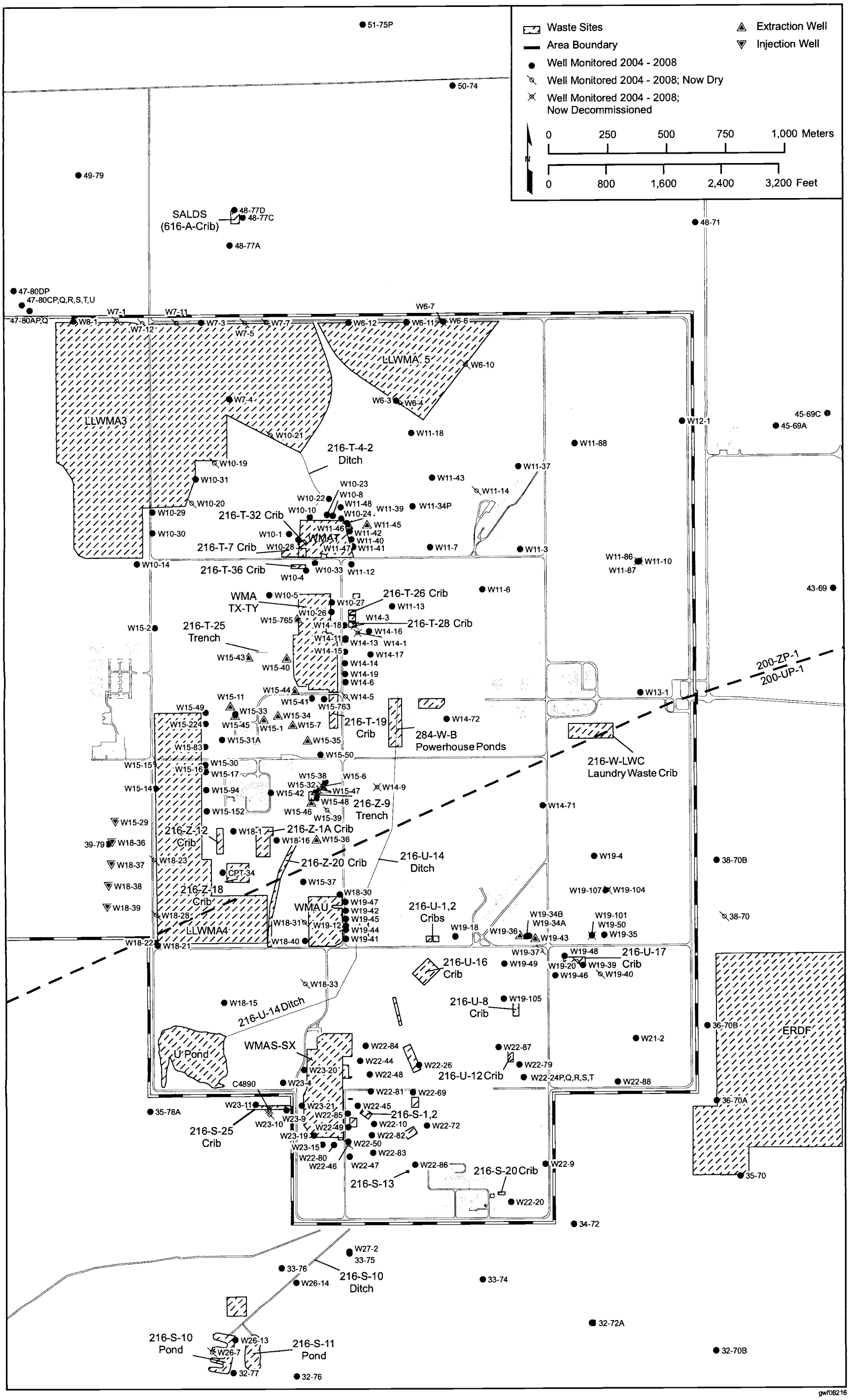

**Figure 2.8-2. 200 West Area Water-Table Map, March 2008.**

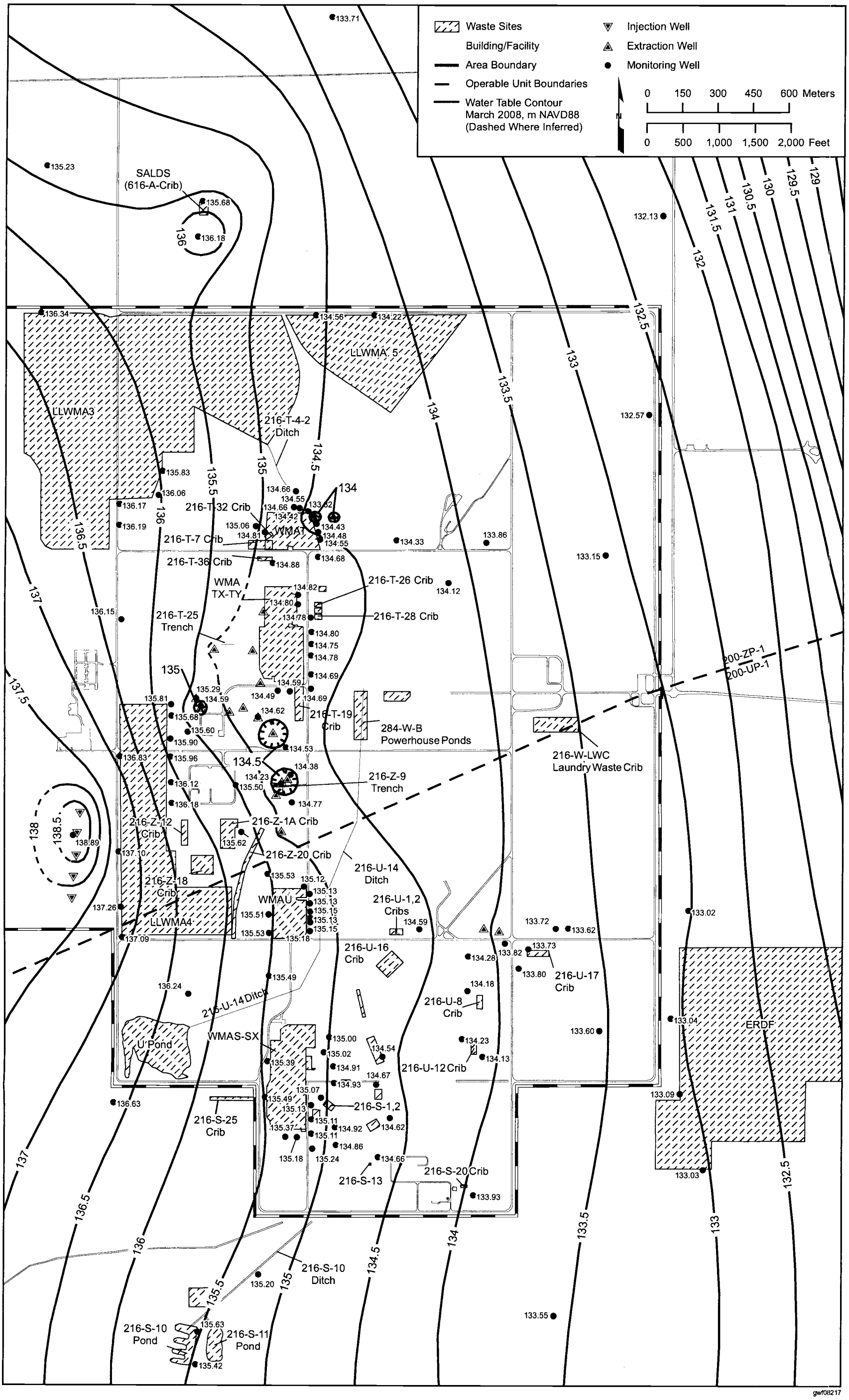

**Figure 2.8-3. Average Carbon Tetrachloride Concentrations in the 200 West Area, Upper Part of Unconfined Aquifer.**

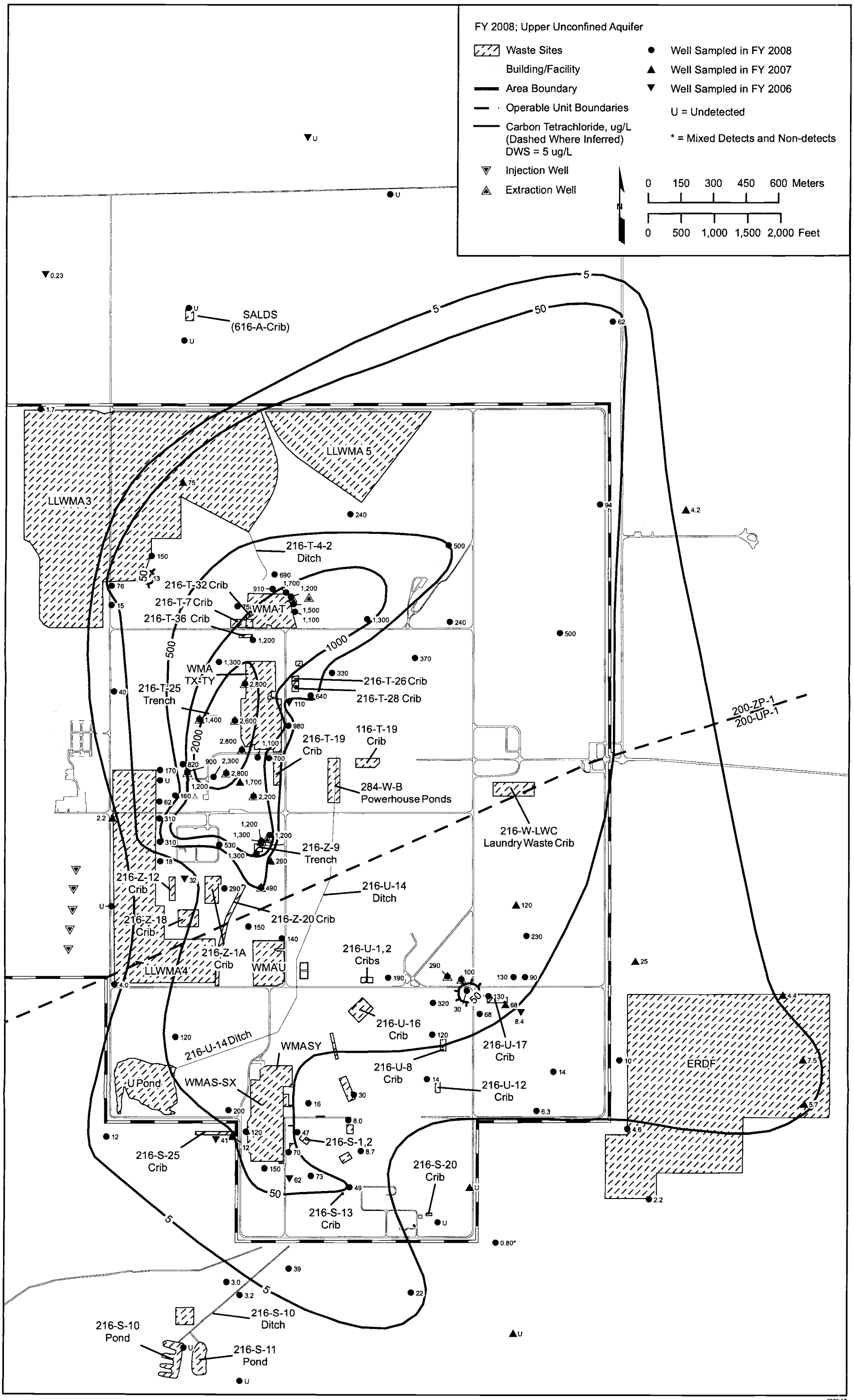

**Figure 2.8-4. Carbon Tetrachloride Concentration in Well 699-48-71, Northeast of the 200 West Area.**

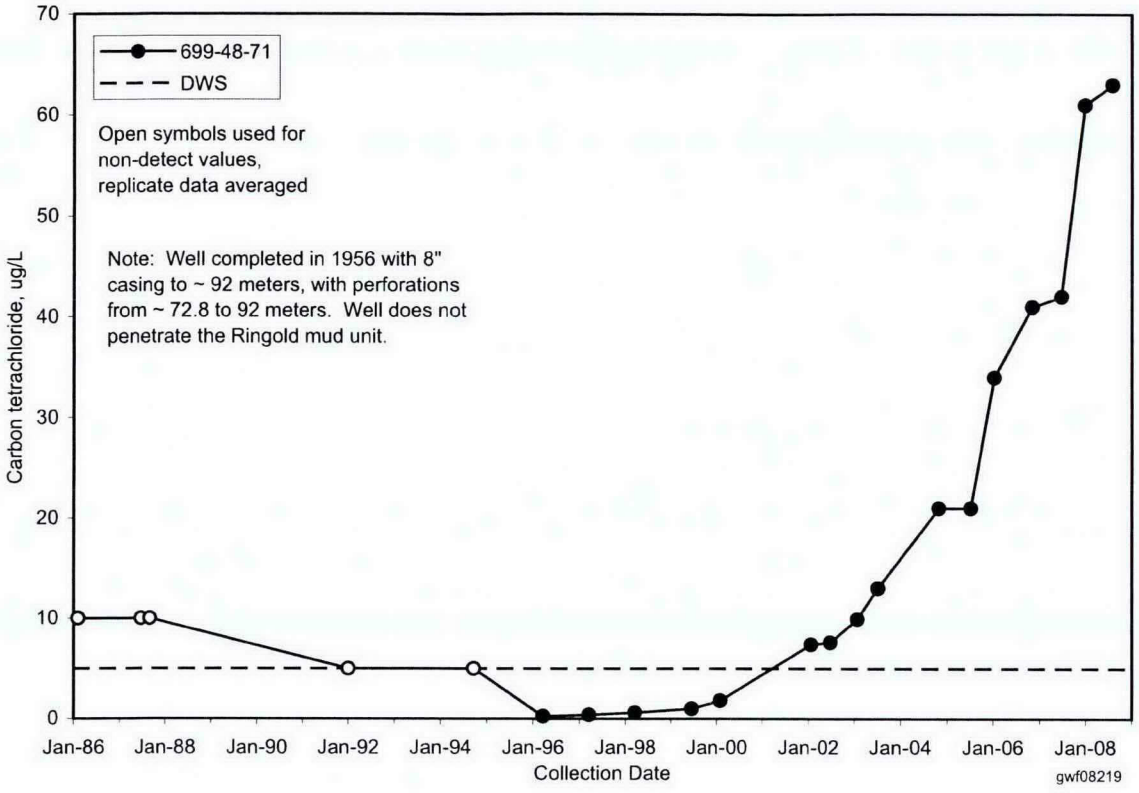


**Figure 2.8-5. Carbon Tetrachloride Concentrations During Drilling in New Wells 299-W11-88, 699-43-69, and 699-45-69C.**

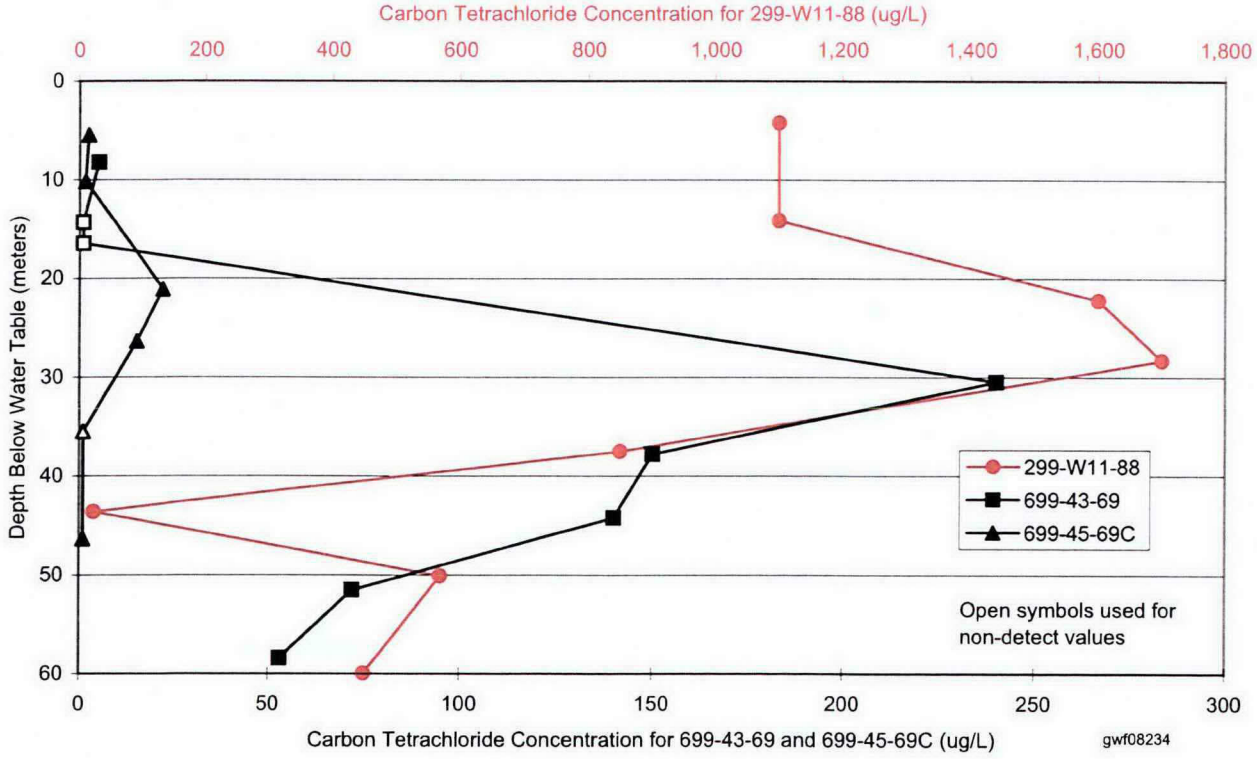

**Figure 2.8-6. Average Trichloroethene Concentrations in Central and Northern 200 West Area, Upper Part of Unconfined Aquifer.**

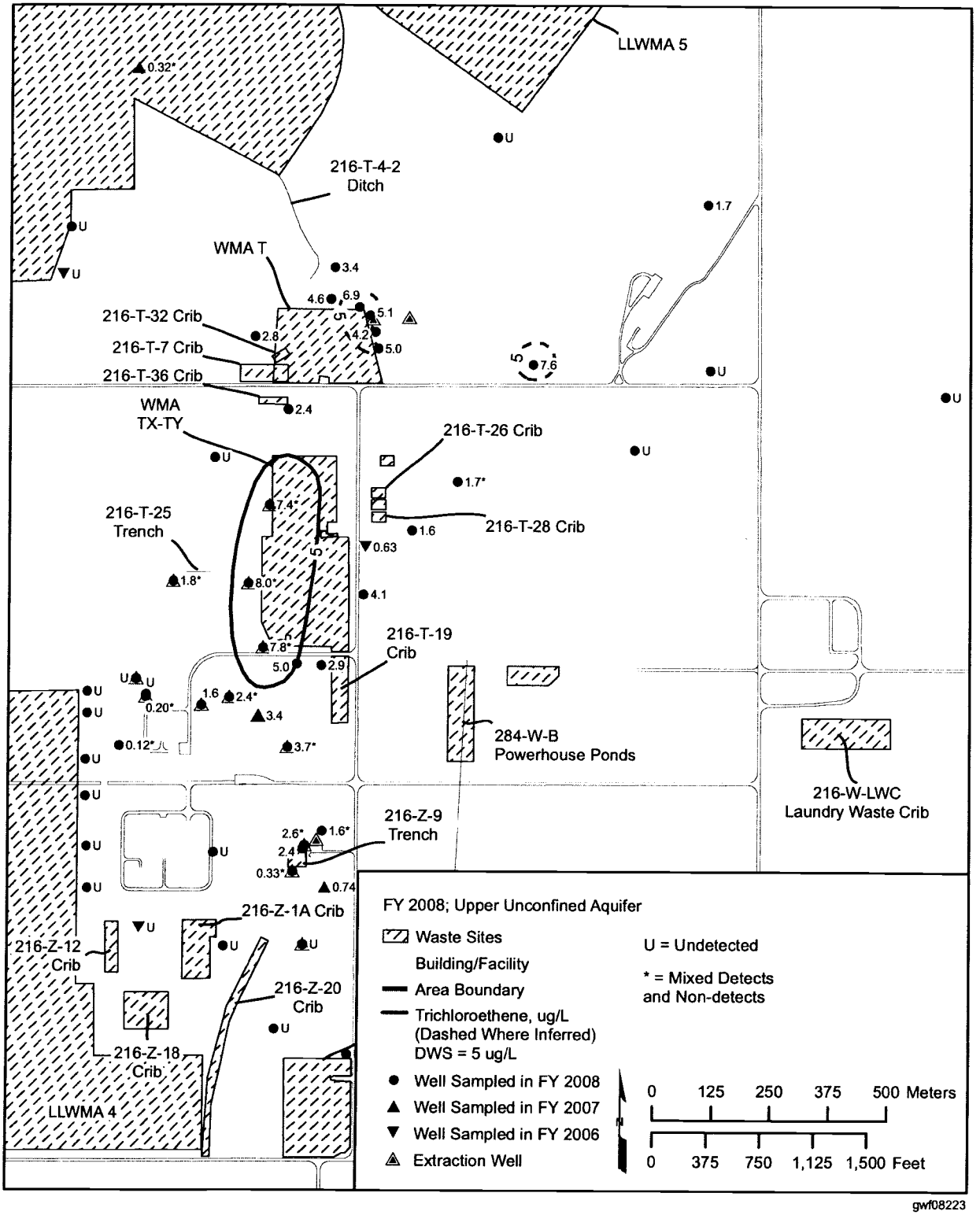

**Figure 2.8-7. Average Nitrate Concentrations in Central and Northern 200 West Area, Upper Part of Unconfined Aquifer.**

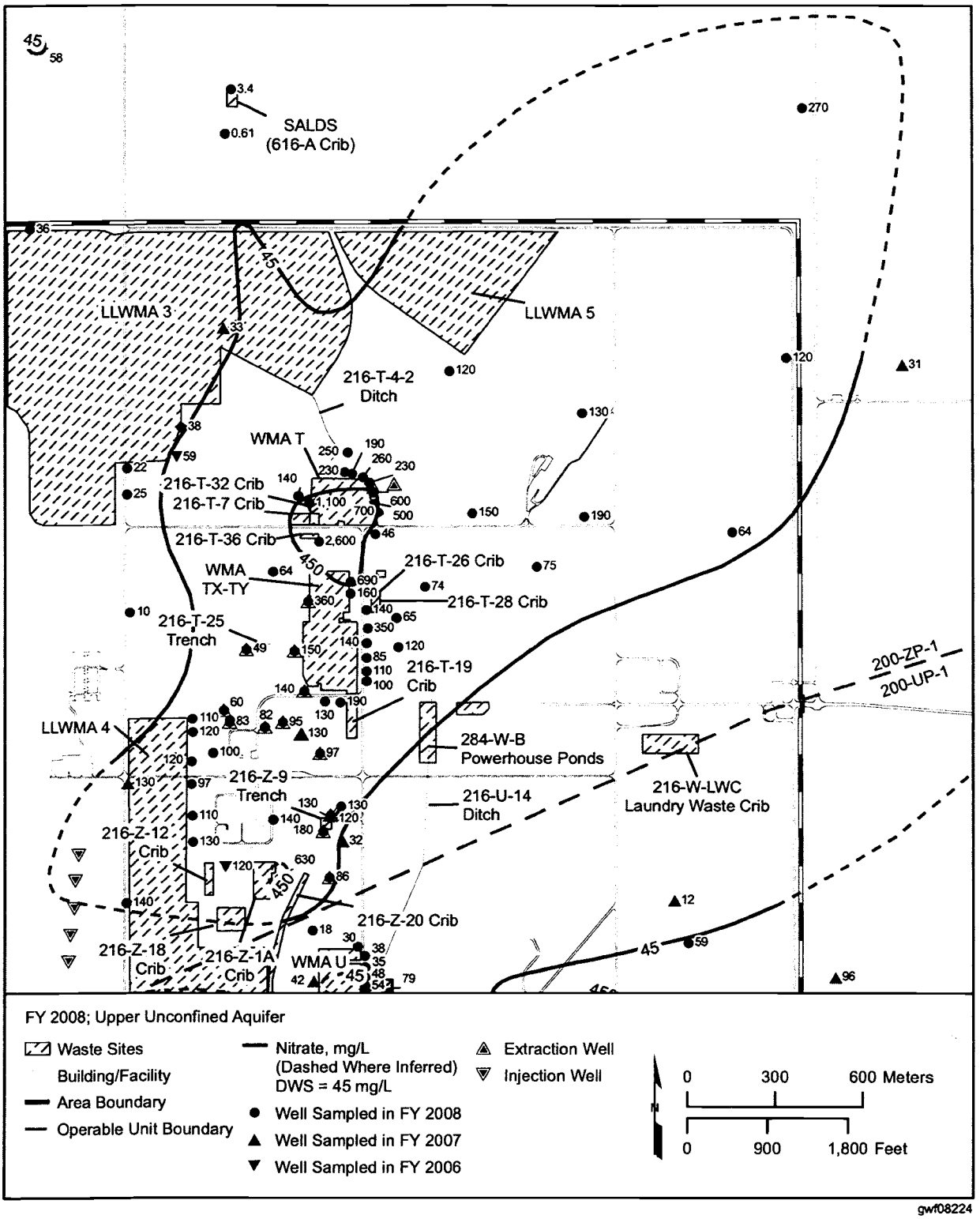

**Figure 2.8-8. Nitrate Concentrations During Drilling in New Wells 299-W11-88, 699-43-69, and 699-45-69C.**

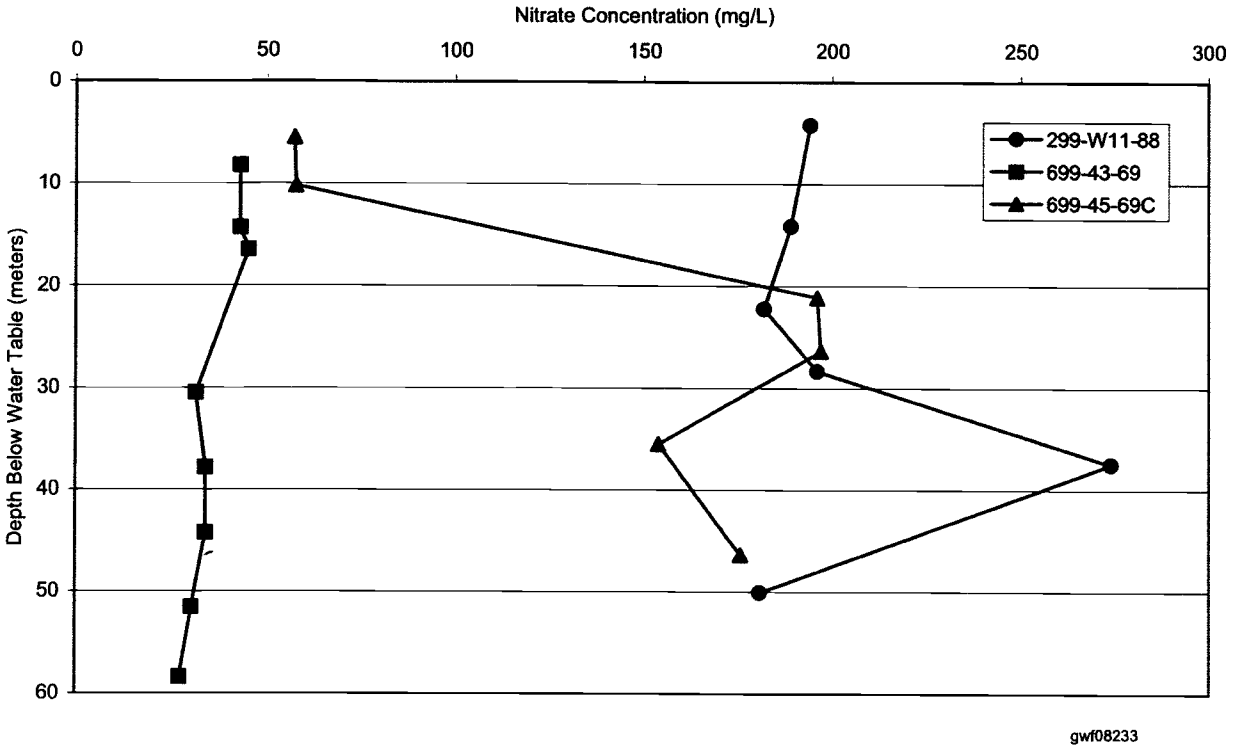

**Figure 2.8-9. Average Filtered Chromium Concentrations near Waste Management Areas T and TX-TY, Upper Part of Unconfined Aquifer.**

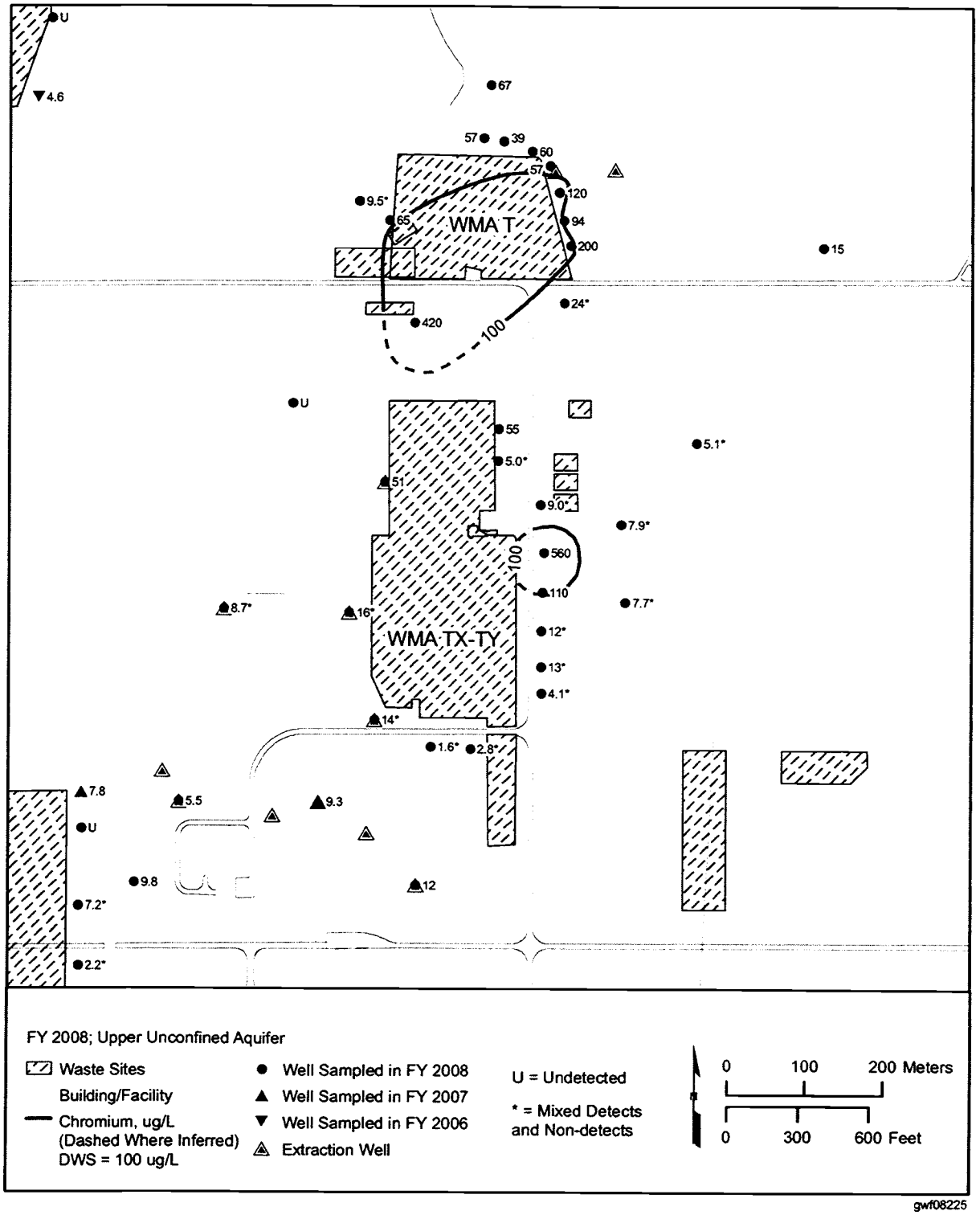

**Figure 2.8-10. Average Tritium Concentrations in Northern 200 West Area, Upper Part of Unconfined Aquifer.**

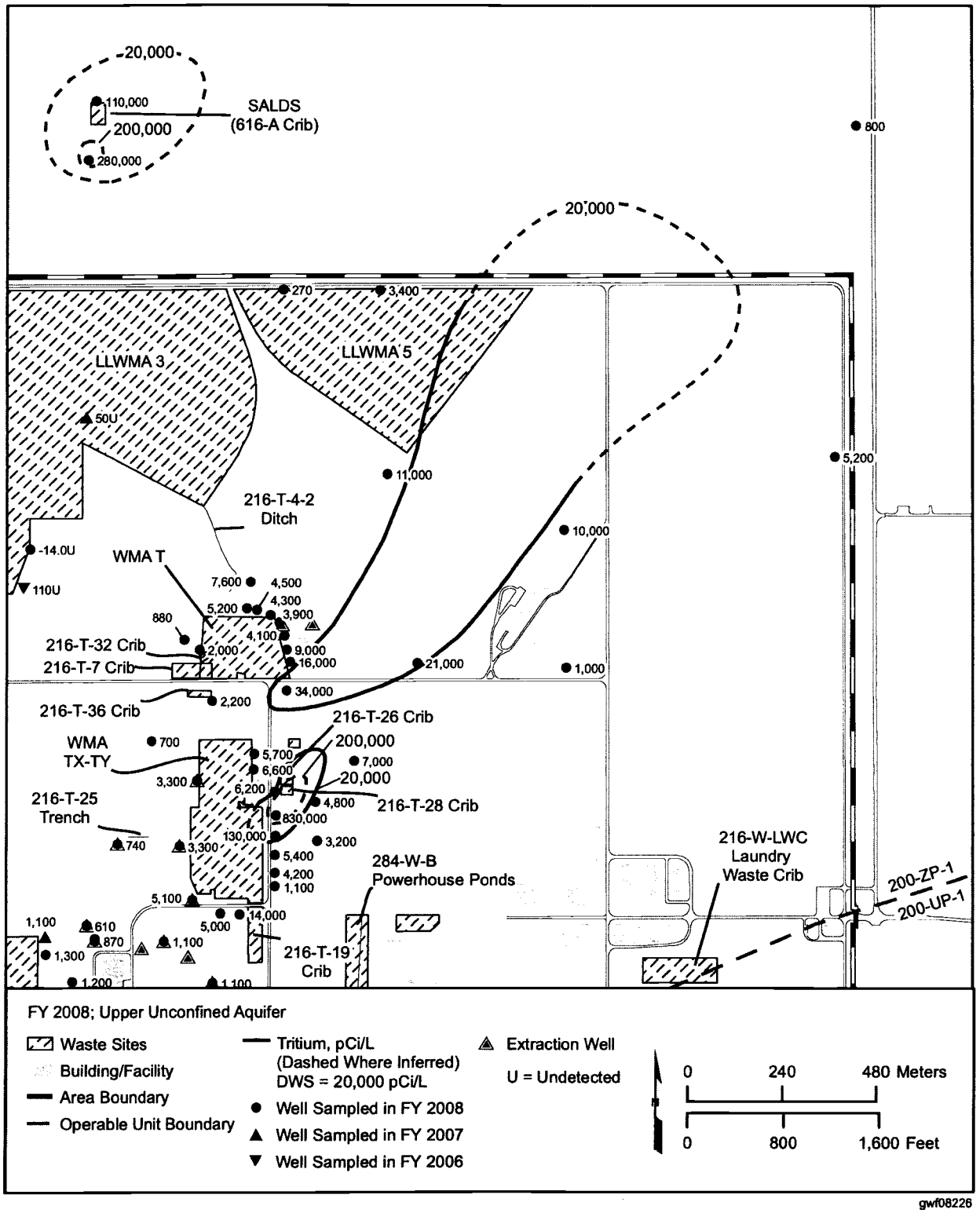

**Figure 2.8-11. Tritium Concentrations During Drilling in New Wells 299-W11-88, 699-43-69, and 699-45-69C.**

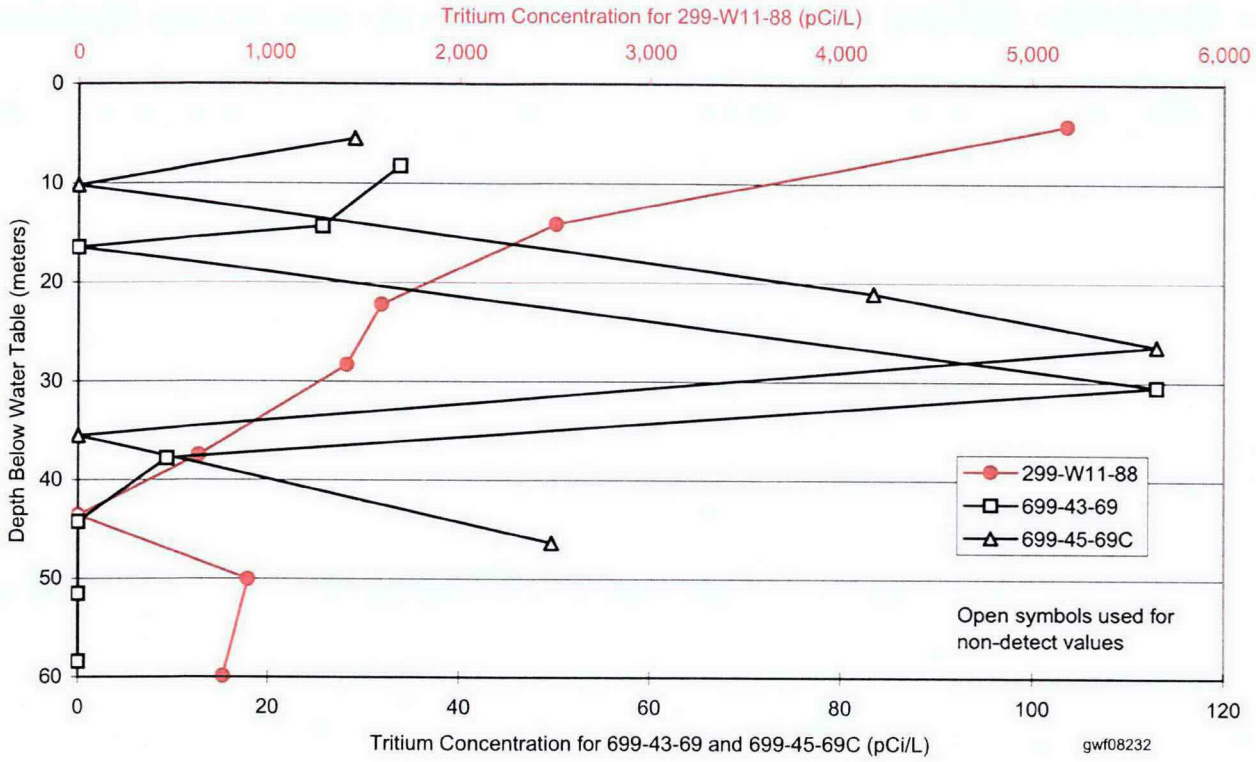

**Figure 2.8-12. Average Iodine-129 Concentrations in Northern 200 West Area, Upper Part of Unconfined Aquifer.**

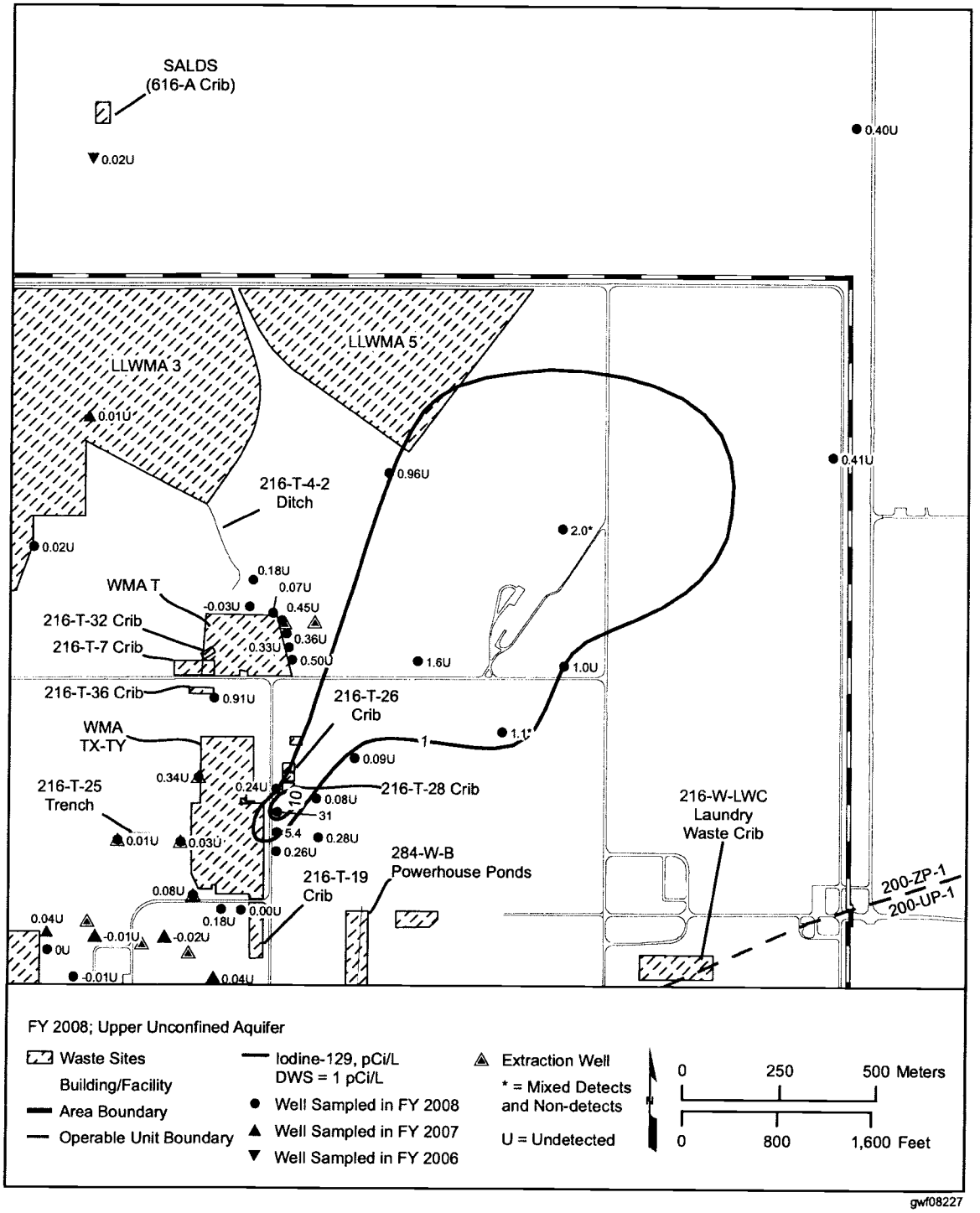


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**Figure 2.8-13. Average Technetium-99 Concentrations in Northern 200 West Area, Upper Part of Unconfined Aquifer.**

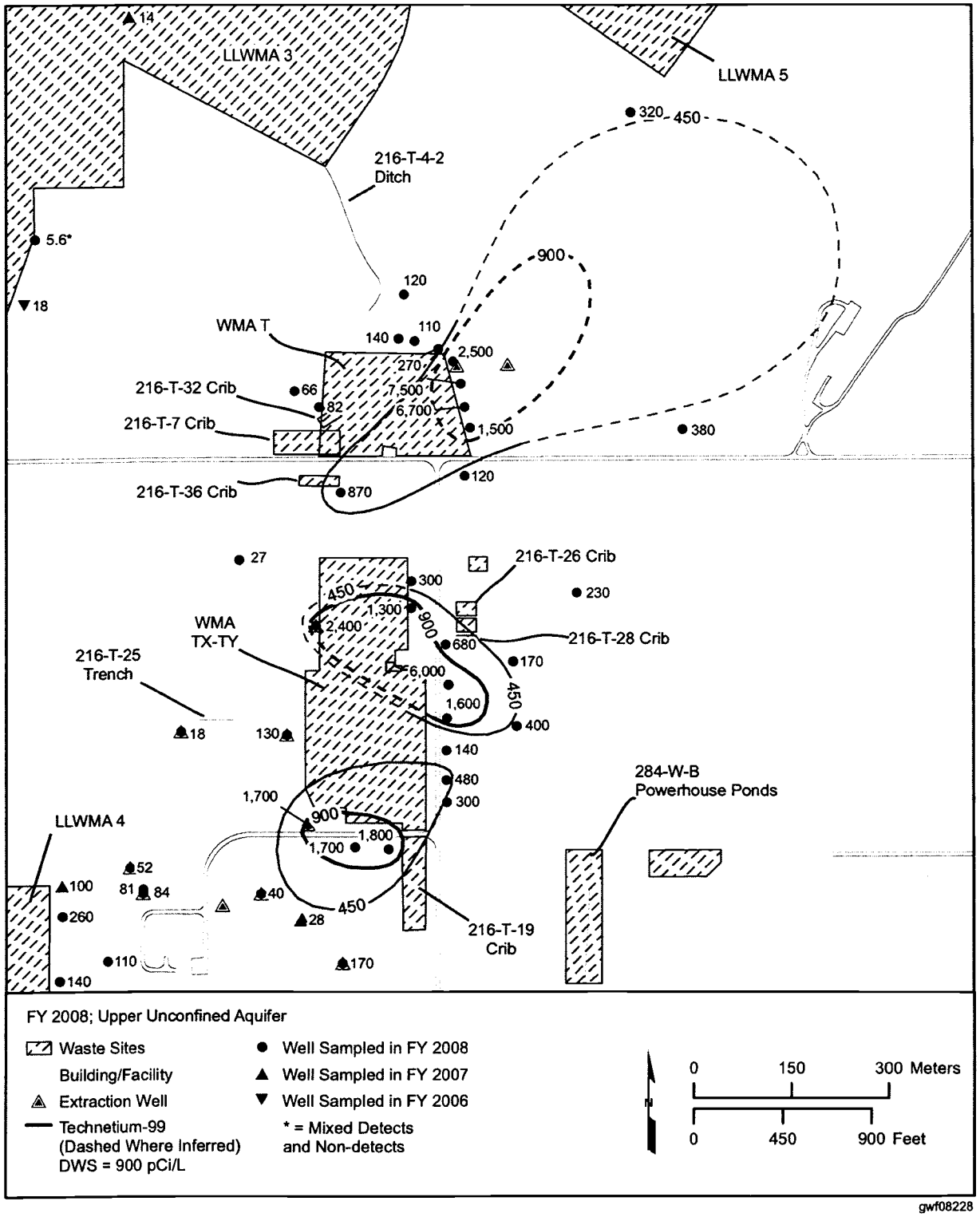


**Figure 2.8-14. Technetium-99 Concentrations During Drilling in New Wells 299-W11-88, 699-43-69, and 699-45-69C.**

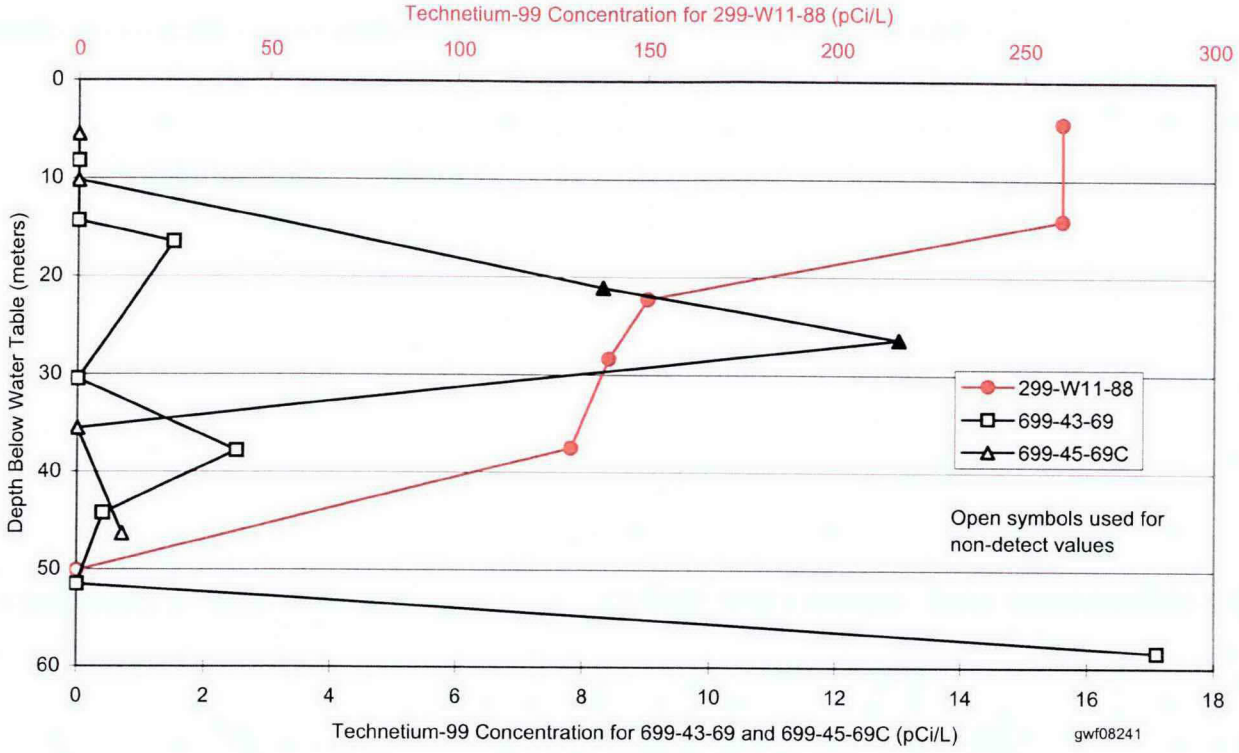



**Figure 2.8-15. Carbon Tetrachloride Concentrations in Four Wells Converted to Extraction Wells in FY 2008.**

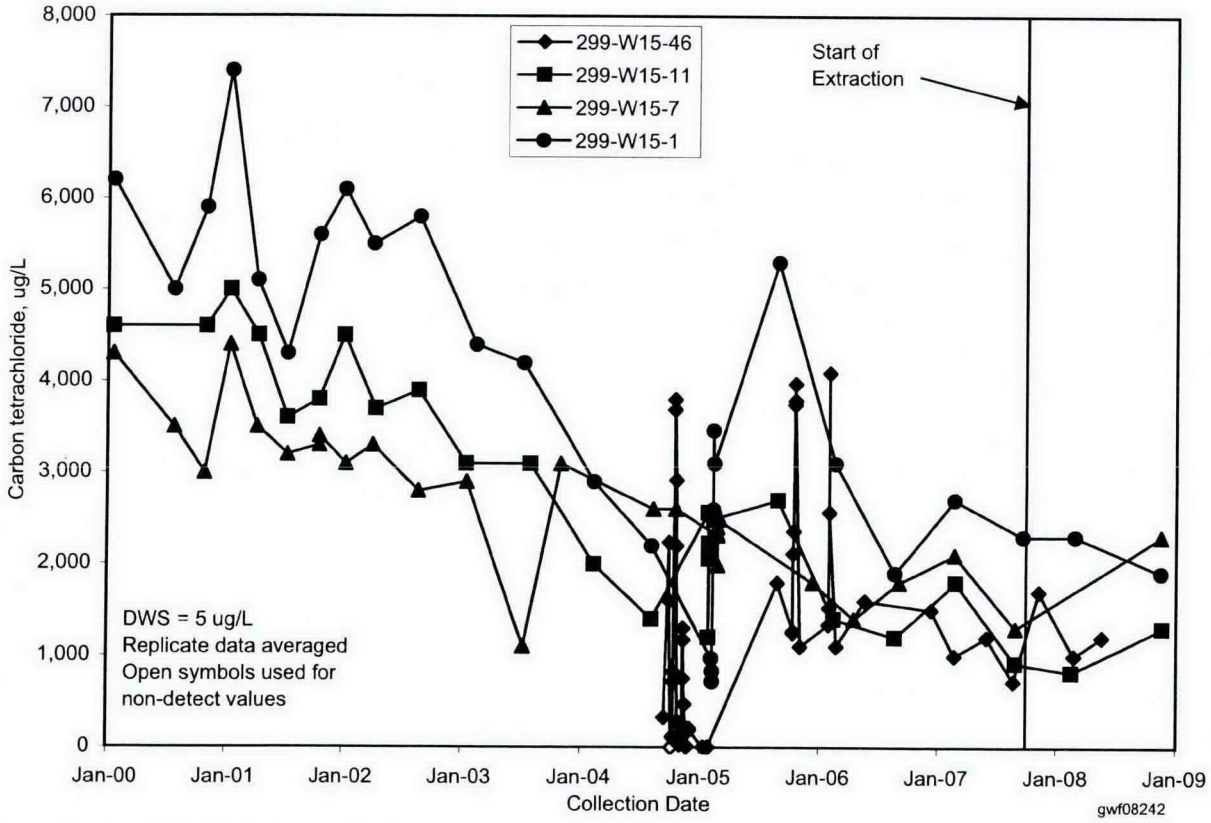


**Figure 2.8-16. Carbon Tetrachloride Concentrations in the 200-ZP-1 Pump-and-Treat System.**

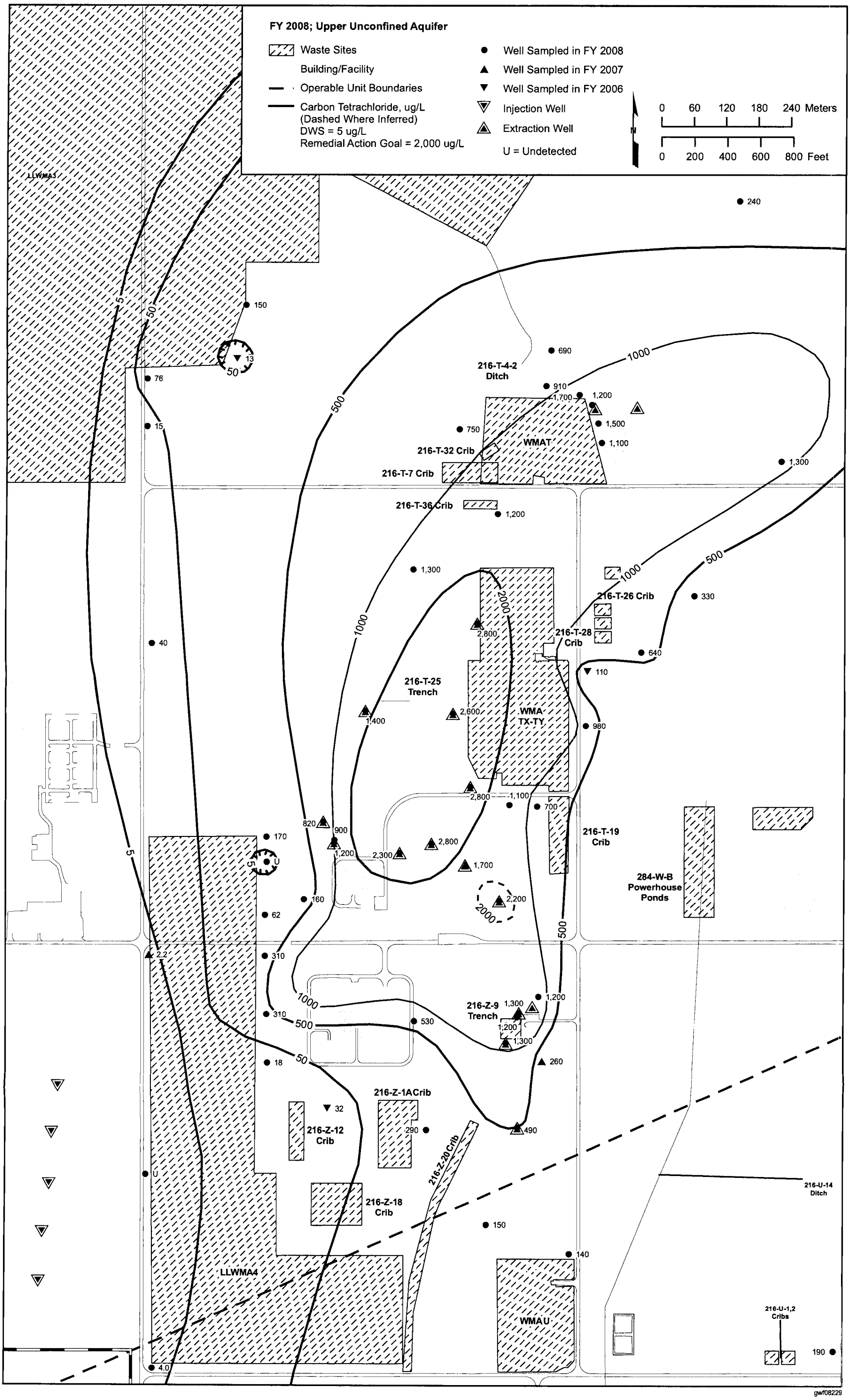
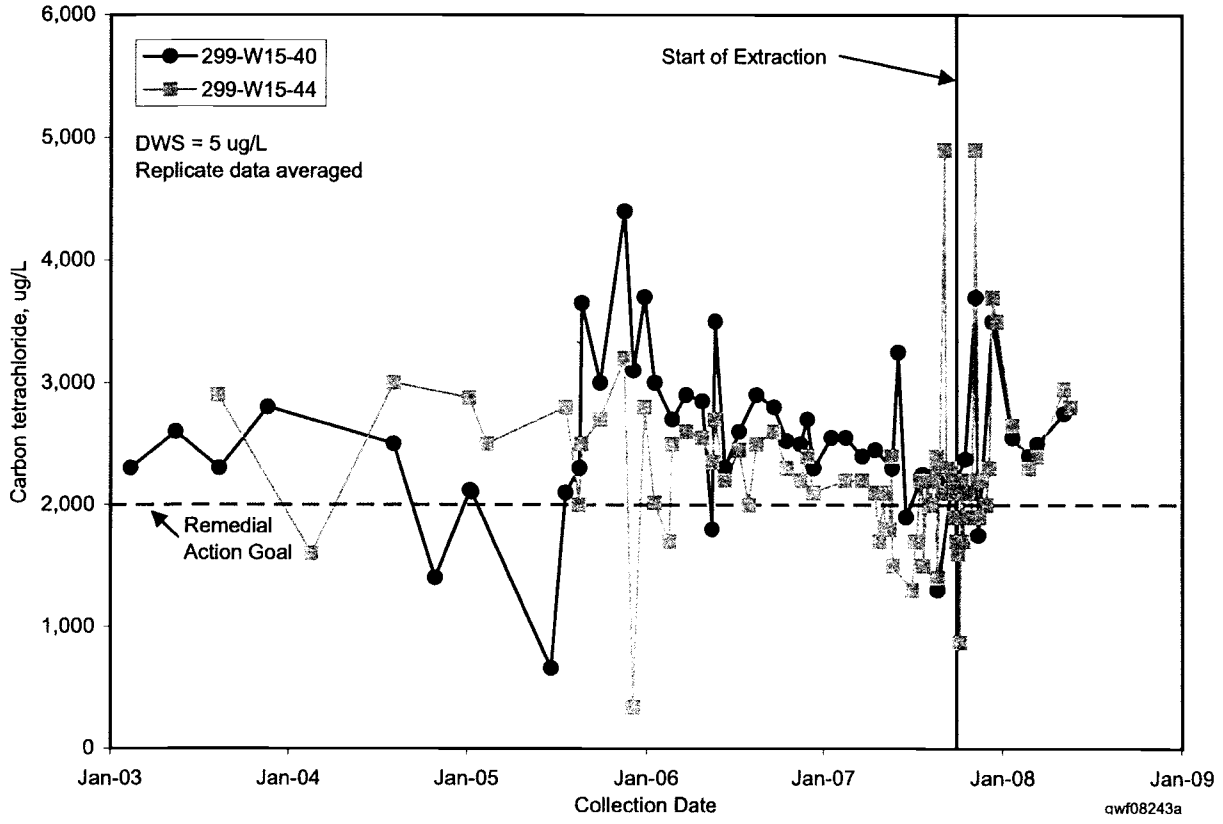


**Figure 2.8-17. Carbon Tetrachloride Concentrations Exceeding the Remedial Action Goal.**



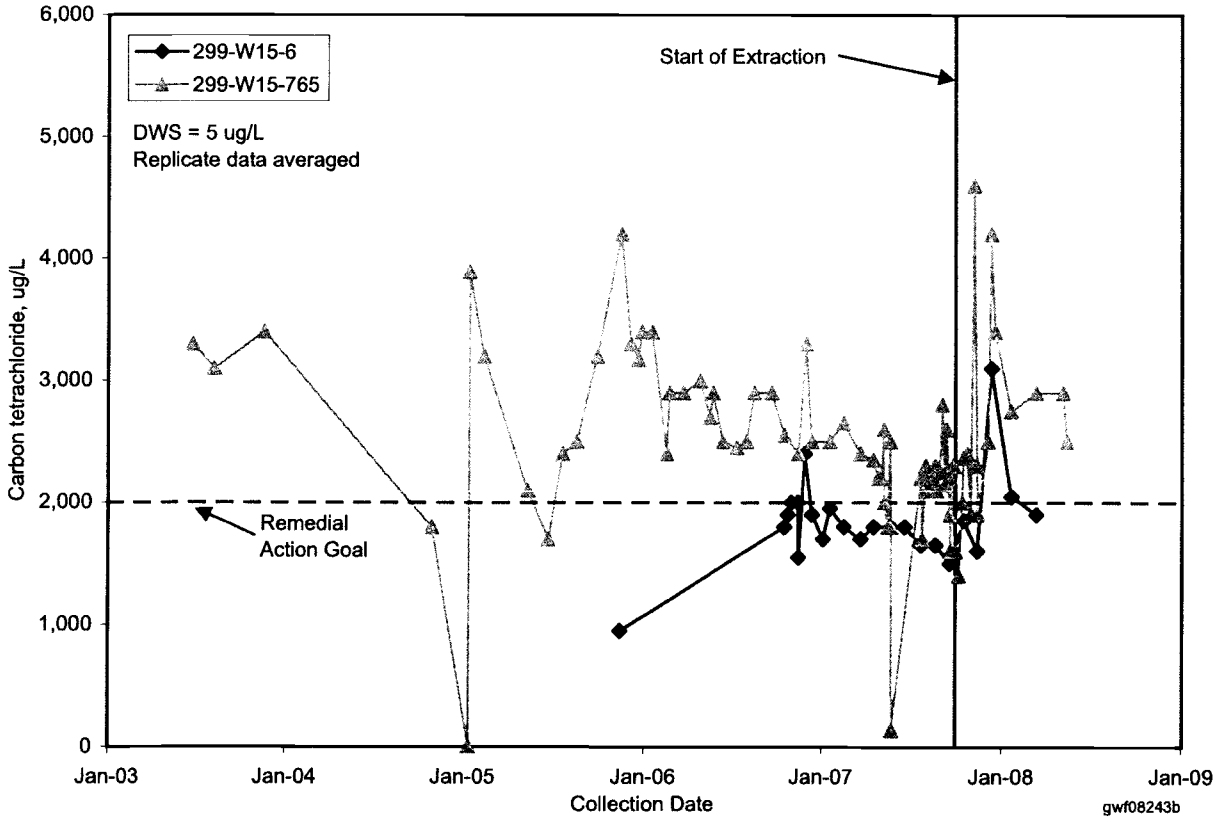




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**Figure 2.8-18. Hydrographs for Selected Wells in Waste Management Area T.**

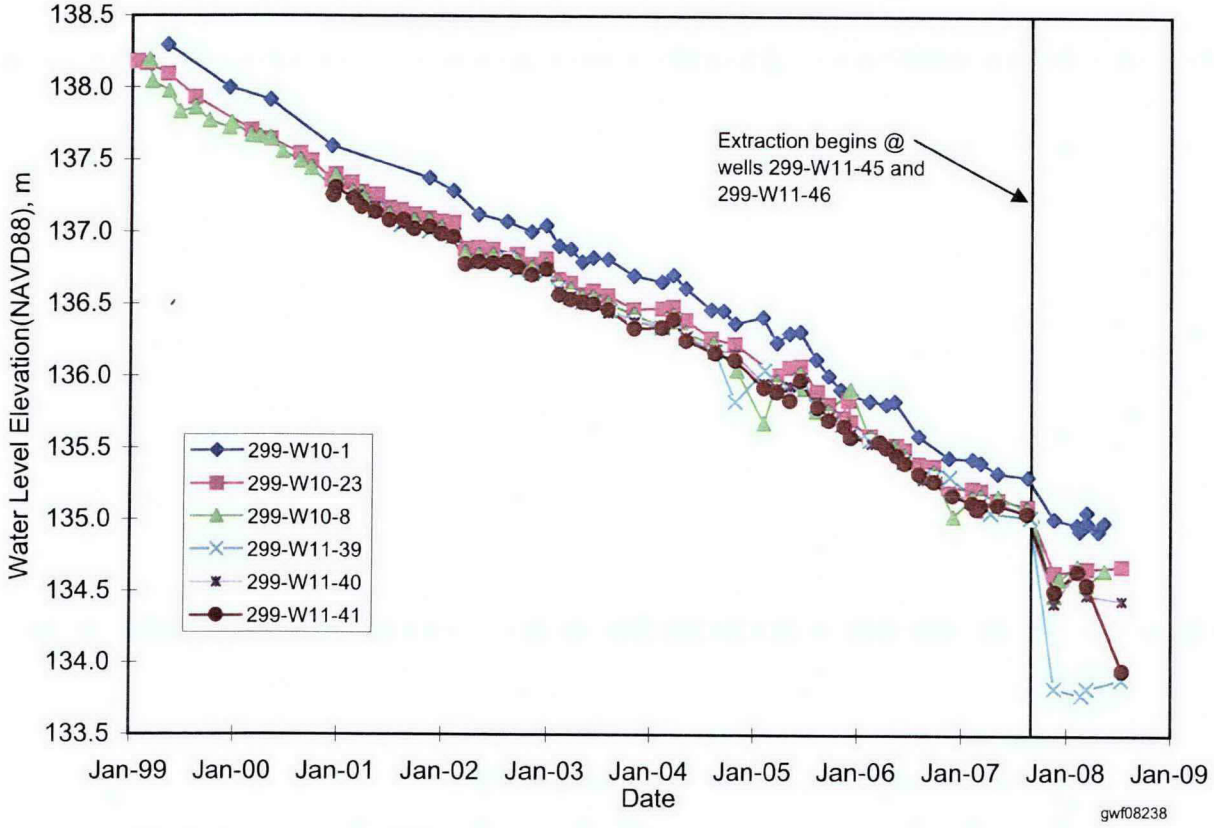



**Figure 2.8-19. Technetium-99 Concentrations in Selected Water-Table Wells Downgradient of Waste Management Area T.**

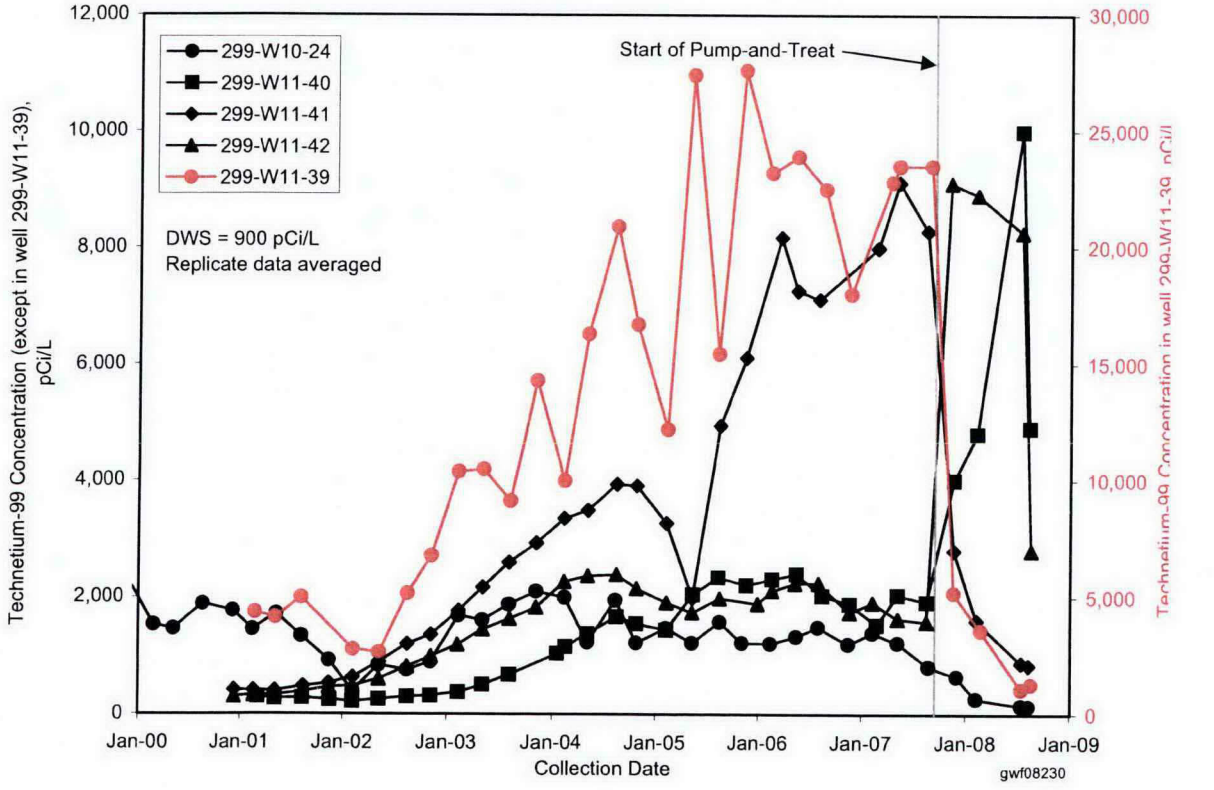


**Figure 2.8-20. Technetium-99 Concentrations in Selected Wells Downgradient of Waste Management Area T, Screened at Depth in the Aquifer.**

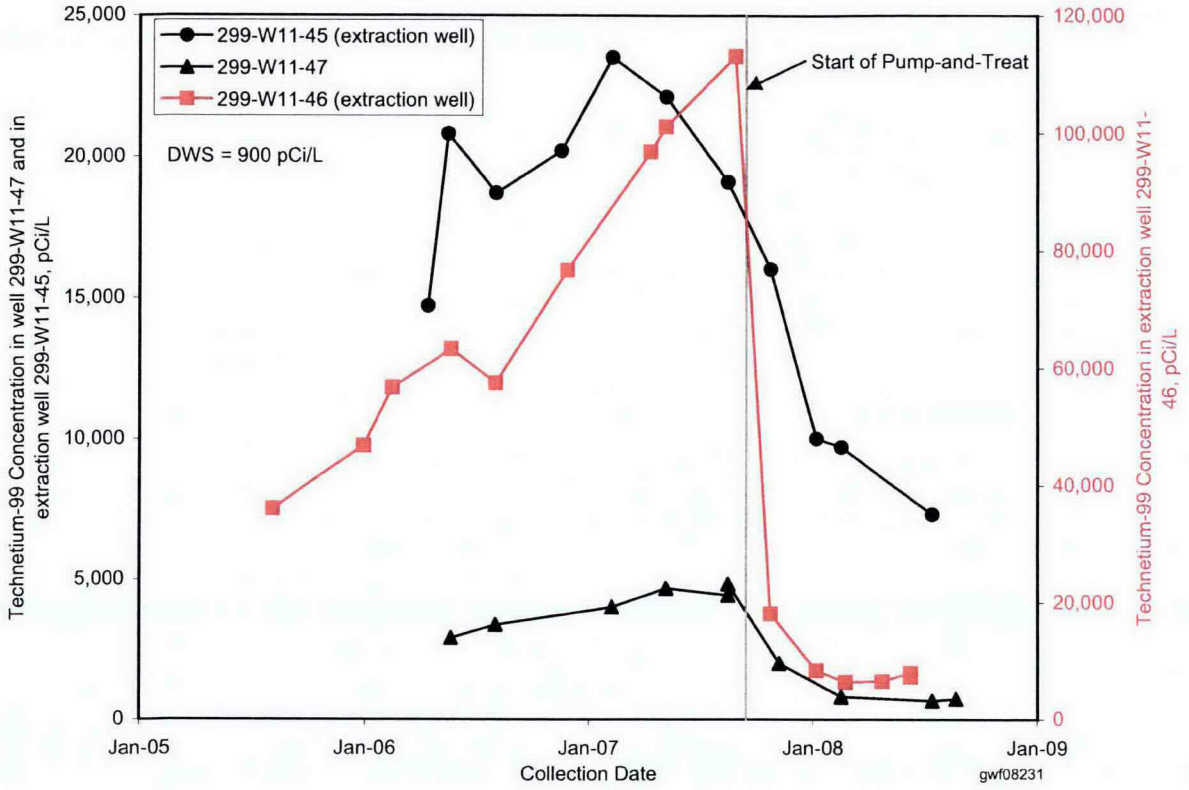



**Figure 2.8-21. Chromium and Iodine-129 Concentrations in Well 299-W14-15 at Waste Management Area TX-TY.**

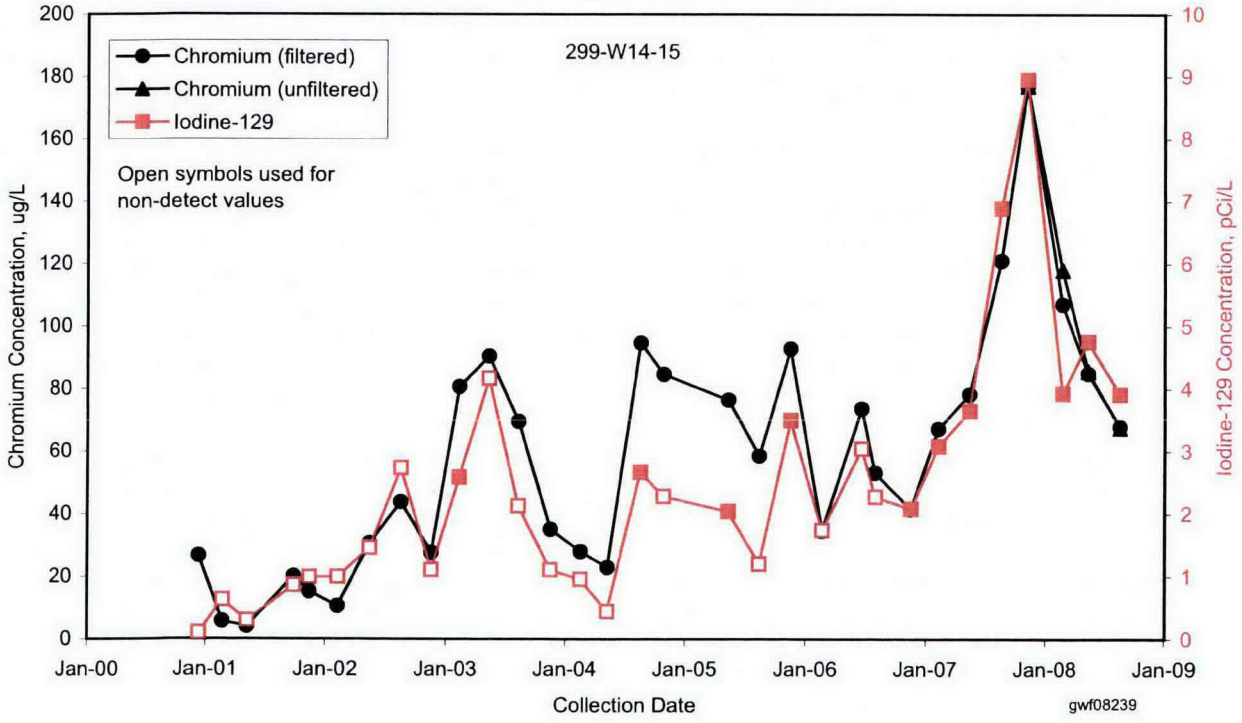


**Figure 2.8-22. Nitrate, Tritium, and Technetium-99 Concentrations in Well 299-W14-15 at Waste Management Area TX-TY.**

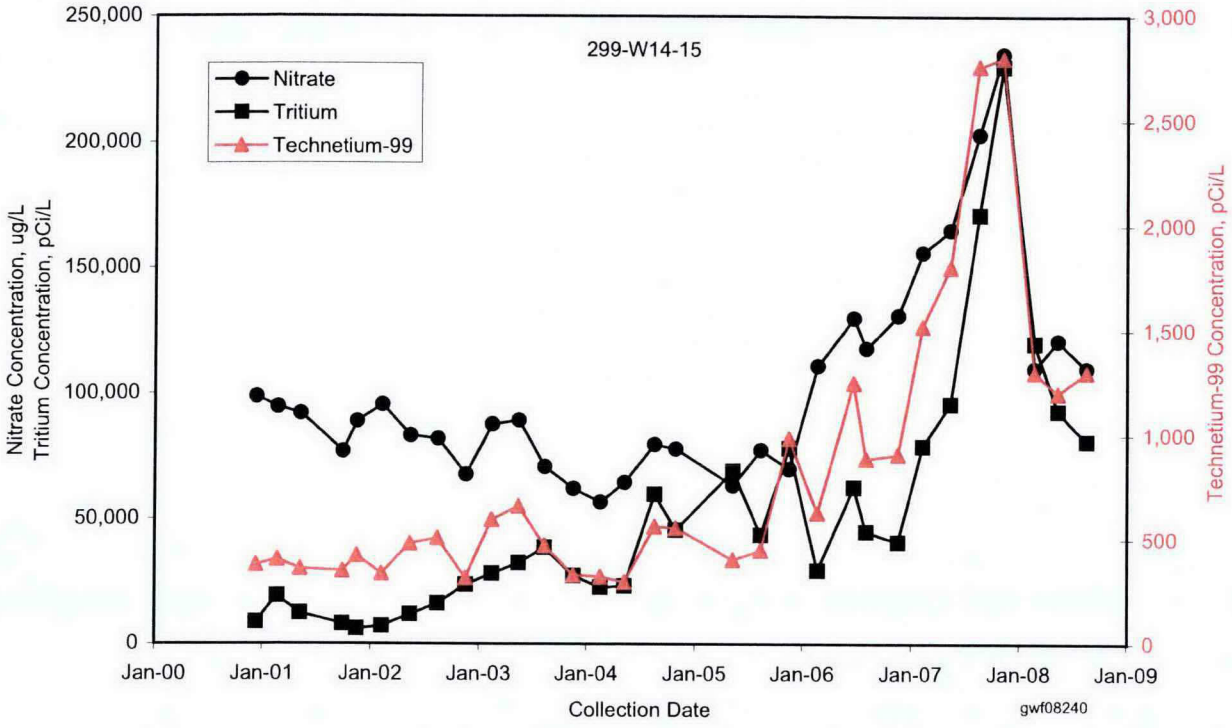
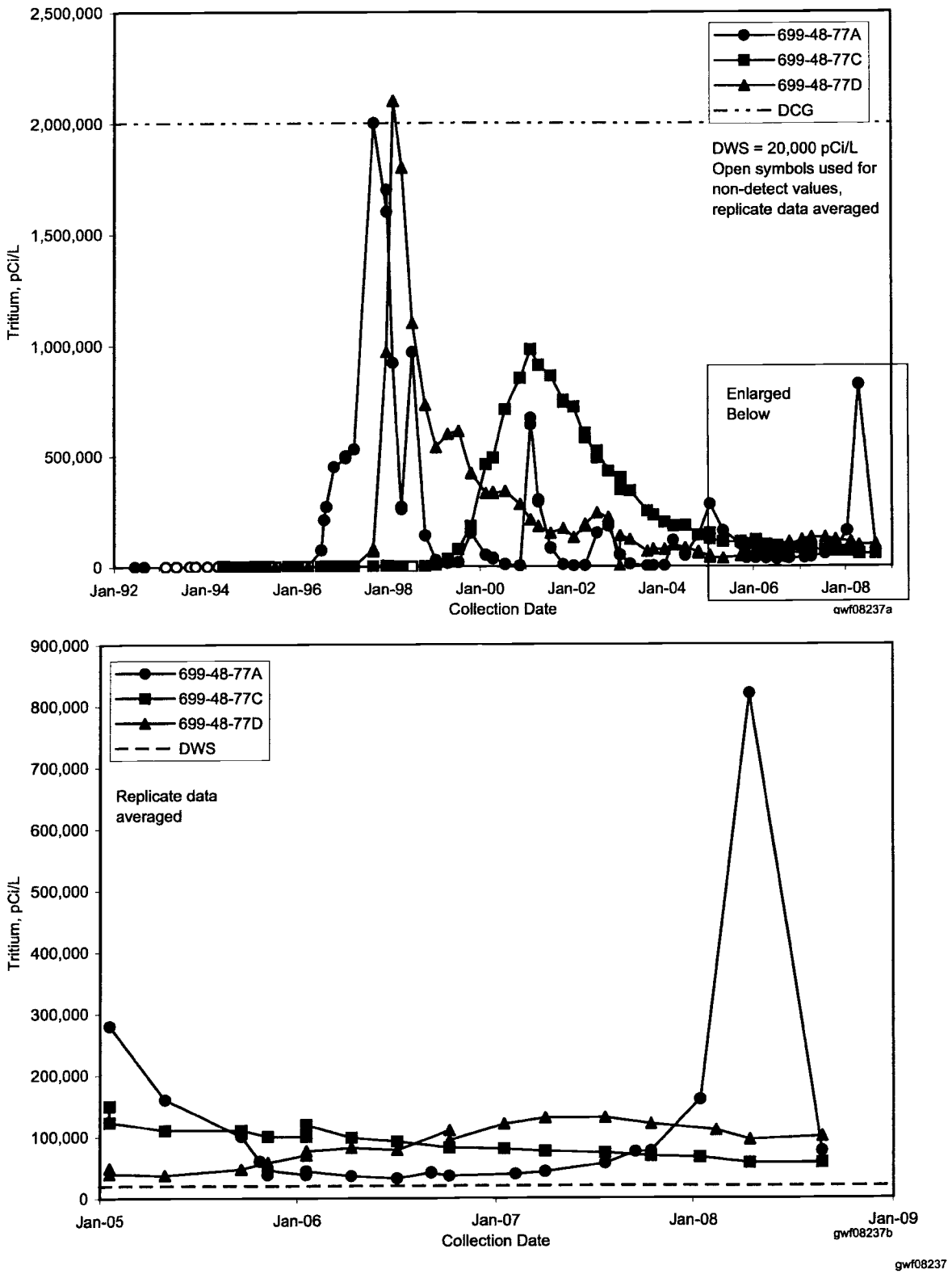


**Figure 2.8-23. Tritium Concentrations in Wells Monitoring the State-Approved Land Disposal Site.**



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# 2.9 200-UP-1 Operable Unit

*J. P. McDonald*

***Technetium-99, uranium, tritium, iodine-129, nitrate, and carbon tetrachloride are the contaminants of greatest significance in groundwater and form extensive plumes within the 200-UP-1 groundwater interest area.***

The 200-UP-1 Operable Unit addresses groundwater contaminant plumes beneath the southern third of the 200 West Area and adjacent portions of the surrounding 600 Area. With the exception of the Environmental Restoration Disposal Facility (ERDF), most of the facilities and waste sites within the operable unit are associated with former operation of the Reduction-Oxidation (REDOX) Plant and U Plant. The operable unit lies within the larger 200-UP-1 groundwater interest area, informally defined to facilitate scheduling, data review, and interpretation (Figure 1.0-1). Figure 2.9-1 shows facilities and wells in the 200-UP-1 Operable Unit.

Groundwater flow in the uppermost unconfined aquifer is primarily to the east within the southern 200 West Area, and northeast in the eastern part of the 200-UP-1 groundwater interest area (Figure 2.9-2). Water levels have been falling in this area since the 1980s. Within the southern 200 West Area, flow directions generally have changed from southeast to east during this time. When U Pond and the 216-U-14 Ditch were active, a groundwater mound resulted in radial flow in the northwest portion of the interest area (e.g., PNNL-16069, *Development of Historical Water Table Maps of the 200 West Area of the Hanford Site (1950-1970)*). Discharges to ground ceased in the mid-1990s, and the groundwater flow resumed its pre-Hanford Site flow direction toward the east. Based on water-level measurements in March 2007 and March 2008, the water-table elevation declined by an average of 0.29 m in the south 200 West Area.

Groundwater monitoring in the 200-UP-1 groundwater interest area is conducted under three regulatory drivers: the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) governs the 200-UP-1 Operable Unit and the ERDF. CERCLA requirements are further subdivided into monitoring conducted to (a) characterize and track all contaminants of concern or potential concern in the operable unit, and (b) evaluate the performance of the pump-and-treat system that removes technetium-99 and uranium from groundwater. *Resource Conservation and Recovery Act of 1976* (RCRA) interim assessment monitoring for hazardous constituents is performed at single-shell tank Waste Management Areas (WMA) U and S-SX, and interim detection monitoring under RCRA is performed at the 216-S-10 Pond and Ditch. Monitoring of radionuclides at these three sites is governed by the *Atomic Energy Act of 1954* (AEA).

Groundwater assessment monitoring was formerly conducted at the 216-U-12 Crib under RCRA, but this site was reclassified as a RCRA past-practice site in June 2007. RCRA groundwater monitoring at this site was discontinued in fiscal year (FY) 2008, but groundwater in the vicinity of the crib was monitored as part of the CERCLA 200-UP-1 Operable Unit.

Eight new monitoring wells were installed within the interest area during FY 2008. Three wells (downgradient wells 699-32-76 and 699-33-75 and upgradient well 699-33-76) were installed at the 216-S-10 Pond and Ditch for both RCRA monitoring and the 200-UP-1 Operable Unit remedial investigation; two downgradient wells were installed at the ERDF to accommodate facility expansion (699-36-66B and 699-37-66); and three wells were installed at other locations for the 200-UP-1 Operable Unit remedial investigation (299-W22-88, 699-33-74, and

699-34-72). All of the new wells were screened at the water table. Well locations are shown in Figure 2.9-1. Sampling results for these wells are included in the following sections, as appropriate.

Some of the main concepts associated with the 200-UP-1 Operable Unit include the following.

- Sources of groundwater contamination included ditches, cribs, waste disposal ponds, and single-shell tank farms that formerly leaked. These facilities are currently inactive, and pumpable liquids have been removed from the tanks. However, the waste sites have not yet been remediated and contamination remains in the vadose zone.
- Technetium-99, uranium, tritium, iodine-129, nitrate, and carbon tetrachloride are the contaminants of greatest significance in groundwater. Technetium-99, nitrate, and chromium plumes from the tank farms are generally growing in areal extent, while the more extensive nitrate, iodine-129, and tritium plumes are dispersing naturally.
- Groundwater contaminants occur mostly in the upper part of the unconfined aquifer. Carbon tetrachloride is an exception; concentrations generally increase with depth in the eastern part of the 200 West Area. The sources of the carbon tetrachloride contamination are in the 200-ZP-1 Operable Unit.
- Results from new monitoring wells indicated the carbon tetrachloride plume extends farther south than previously interpreted.
- Concentrations of the mobile tank waste constituents, chromium, nitrate, and technetium-99 increased downgradient from the S Tank Farm.
- An interim action pump-and-treat system recovered 3.5 kg of uranium and 4.6 g of technetium-99 from the aquifer during the fiscal year. Since startup in 1994, 216 kg of uranium and 124 g of technetium-99 have been recovered. Concentrations of these constituents within the pump-and-treat area were below their respective remedial action goals of 480 µg/L and 9,000 pCi/L.
- The U.S. Department of Energy (DOE) installed six new wells to support the operable unit's remedial investigation.
- Two wells were decommissioned and two new wells were installed to accommodate expansion of the ERDF.
- Three RCRA sites are located in the operable unit. Assessment monitoring continued at WMAs S-SX and U. Three of the new monitoring wells installed for the operable unit's remedial investigation will be monitored for the 216-S-10 Pond and Ditch, replacing wells that had gone dry. The site continued to be monitored under a detection program.

The following sections provide details about the contaminant plumes and concentration trends for the contaminants of concern and operable unit activities under CERCLA, RCRA, and AEA monitoring.

## 2.9.1 Groundwater Contaminants

Large-scale waste disposal at the 200-UP-1 groundwater interest area began during the early 1950s when plutonium separation operations began at the REDOX Plant and uranium recovery operations began at U Plant. In general, the high-level radioactive waste was stored in underground storage tanks, while other liquid waste streams were sent to ponds and cribs. Groundwater plumes of nitrate, tritium, and iodine-129 formed from the pond and crib waste. These plumes expanded as effluent disposal operations continued. Effluent disposal to the ponds and cribs ceased during the 1990s. At present, the groundwater plumes from these sources are dispersing naturally. However, constituents of lower mobility in the vadose zone beneath the ponds and cribs may potentially reach the water table in the future and affect groundwater quality.

***Plume areas (square kilometers) above the drinking water standard at the 200-UP-1 Operable Unit:***

***Chromium — 1.10***
***Iodine-129 — 4.60***
***Nitrate — 6.14***
***Technetium-99 — 0.30***
***Tritium — 8.05***
***Uranium — 0.42***

****Carbon tetrachloride included in Section 2.8.***

Within the tank farms (WMAs U and S-SX), some of the underground storage tanks have leaked, resulting in contamination of the vadose zone beneath the tanks. Some of this contamination has migrated downward and reached the water table (e.g., PNNL-11810, *Results of Phase I Groundwater Quality Assessment for Single-Shell Tank Waste Management Area S-SX at the Hanford Site*). Currently, plumes of nitrate, technetium-99, and chromium from the tank farms are found in groundwater, are generally growing in areal extent, and exhibit increasing constituent concentrations. In addition, carbon tetrachloride is migrating into the 200-UP-1 groundwater interest area from the 200-ZP-1 groundwater interest area.

***Groundwater plumes of chromium, nitrate, and technetium-99 from the S-SX Tank Farms are generally growing in areal extent.***

Technetium-99, uranium, tritium, iodine-129, nitrate, and carbon tetrachloride are the contaminants of greatest significance in groundwater and form extensive plumes within the region. In addition to these constituents, high-priority contaminants of concern include strontium-90, trichloroethene, chloroform, chromium, cadmium, and arsenic (DOE/RL-92-76, *Remedial Investigation/Feasibility Study Work Plan for the 200-UP-1 Groundwater Operable Unit*). The following sections provide an overview of the contaminant plumes and contaminants of concern for the 200-UP-1 groundwater interest area. These sections are a summary of the combined results of CERCLA, RCRA, and AEA monitoring performed in this area with the focus being the upper part of the unconfined aquifer. Information on the vertical distribution of contaminants in the aquifer is given where available.

### 2.9.1.1 Technetium-99

Technetium-99 concentrations occur above the drinking water standard (900 pCi/L) in three regions of the 200-UP-1 groundwater interest area: downgradient from the 216-U-1/2 Cribs, at WMA S-SX, and at WMA U (Figure 2.9-3). A technetium-99 plume originates from the 216-U-1/2 Cribs, which were active in the 1950s and 1960s. The plume extends ~1.5 to 2 km east into the 600 Area, but mostly at levels below the drinking water standard. When effluent was disposed at the nearby 216-U-16 Crib in the mid-1980s, it migrated north along a caliche layer and mobilized the technetium-99 and uranium in the soil column beneath the 216-U-1/2 Cribs, adding contaminant mass to the groundwater plume (DOE/RL-92-76). Historically, the highest measured technetium-99 concentration in the 216-U-1/2 Cribs plume was 41,000 pCi/L in well 299-W19-24 (west of the 216-U-17 Crib) during October 1989.

An interim remedial action pump-and-treat system operated in the central part of the 216-U-1/2 Cribs plume from 1994 until the initiation of a rebound study in early 2005. The results of the rebound study were described in PNNL-16346 and WMP-30847. Groundwater extraction resumed in April 2007. The pump-and-treat system has been successful in removing technetium-99 from the aquifer. Technetium-99 concentrations exceed the 900 pCi/L drinking water standard in both extraction wells (299-W19-36 and 299-W19-43), but are below the drinking water standard at all of the monitoring wells within the pump-and-treat area. In addition, all but one sample result from the extraction wells were below the remedial action goal of 9,000 pCi/L. In October 2007, technetium-99 was reported at 11,000 pCi/L in well 299-W19-36, but declined below the remedial action goal for three later sampling events during FY 2008. Section 2.9.2 provides a more thorough discussion of the pump-and-treat activities.

***Concentrations of technetium-99 in well 299-W23-19, at Waste Management Area S-SX, averaged 55,000 pCi/L during FY 2008.***

At WMA S-SX, a technetium-99 plume originates from the southwestern corner of the WMA and another plume originates from the northern part. The highest technetium-99 concentrations within the interest area occur in the southern plume at well 299-W23-19 (located inside the SX Tank Farm). During FY 2008, concentrations remained relatively stable in this well, fluctuating between 46,000 and 67,000 pCi/L (Figure 2.9-4). The southern plume from WMA S-SX represents a growing contamination issue because the plume is increasing in areal extent and concentrations are increasing in many of the downgradient wells. The extent of this plume at the 450 pCi/L concentration level was reinterpreted based on the sampling results from new well 699-33-74. This well is located south of the 200 West Area, and technetium-99 is present in the completed well at 420 pCi/L. An analysis of historical groundwater flow rates and directions, as well as contaminant ratios, in the new well indicate that WMA S-SX was the source of this technetium-99. The plume migrated to the south in response to the water-table mound formerly beneath U Pond.

The northern plume at WMA S-SX originates from the S Tank Farm. Concentrations began increasing in this plume during FY 2007 and continued to increase during early FY 2008. In well 299-W22-44, the technetium-99 concentration increased from 10,000 pCi/L during September 2007 to 14,000 pCi/L during March 2008, and then remained at that level for the remainder of FY 2008. Concentrations also have begun to increase in far downgradient well 299-W22-26, where the technetium-99 concentration averaged 3,900 pCi/L during FY 2008. Technetium-99 concentrations remain low in upgradient well 299-W23-20, confirming that the S Tank Farm is the source. The recent concentration increases in the northern plume indicates that it is a growing contamination issue. Section 2.9.3.2 provides information about technetium-99 at this WMA.

***Both the northern and southern plumes from Waste Management Area S-SX represent growing contamination issues.***

Technetium-99 concentrations in the downgradient wells at WMA U are elevated compared to concentrations in the upgradient wells. This indicates the U Tank Farm is a source of technetium-99 contamination (PNNL-13282, *Groundwater Quality Assessment for Waste Management Area U: First Determination*). However, concentrations are very low compared to WMA S-SX. The drinking water standard (900 pCi/L) was exceeded in four wells during FY 2008: 299-W18-30 at ~1,000 pCi/L, 299-W19-42 at ~1,500 pCi/L, 299-W19-45 at ~1,100 pCi/L, and 299-W19-47 at ~1,800 pCi/L. Concentrations are slowly increasing in these four wells. Section 2.9.3.1 provides more information about technetium-99 at this WMA.

The FY 2006 annual report (PNNL-16346) includes maps showing the depth distribution of technetium-99 (and uranium) in groundwater within the 200-UP-1 groundwater interest area. Information for these maps came from depth-discrete groundwater sampling during well installation between FY 2003 and FY 2006. The data indicated three locations relatively deep below the water table within the groundwater interest area where technetium-99 occurred above the drinking water standard. Well 299-W19-46 (near the 216-U-17 Crib) had a concentration of 1,360 pCi/L at 19 m below the water table, with concentrations less than 300 pCi/L above this depth. Well 299-W19-49 (west of the 216-U-17 Crib) had a concentration of 1,320 pCi/L at 28 m below the water table. Well 699-38-70C (north of the ERDF in the 600 Area) had a concentration of 1,200 pCi/L down to the lower mud unit at 33 m below the water table. At all other locations, technetium-99 concentrations above the drinking water standard did not occur beyond the upper ~20 m of the aquifer.

Depth discrete samples were analyzed for technetium-99 in four of the new wells installed during FY 2008. Only one sample result exceeded the drinking water standard: 958 pCi/L in 699-33-74 at 16 m below the water table. One other depth discrete sample collected from this well yielded a concentration of 701 pCi/L at 7 m below the water table. The completed well was screened from 0 to 10 m below the water table, and subsequent sampling yielded a concentration of 420 pCi/L. These data indicate a slight increase in concentrations with depth at this location. At well 699-34-72, technetium-99 was detectable and indicated a downward concentration trend with depth, but all concentrations were less than 100 pCi/L. Technetium-99 was not detected in depth discrete samples from wells 699-33-76 and 299-W22-88.

### 2.9.1.2 Uranium

Within the 200-UP-1 groundwater interest area, uranium primarily occurs in a plume downgradient from the 216-U-1/2 Cribs (Figure 2.9-5) and is associated with the technetium-99 plume. The plume extends a total of ~1.5 km to the east at levels above the 30 µg/L drinking water standard. Uranium adsorbs to soil particles and is not as mobile in the aquifer as technetium-99. The uranium originated from the 216-U-1/2 Cribs that were active in the 1950s and 1960s. As with technetium-99, additional mass was added to the plume when effluent disposed at the nearby 216-U-16 Crib in the mid-1980s migrated north along a caliche layer in the vadose zone and mobilized the technetium-99 and uranium in the soil column beneath the 216-U-1/2 Cribs (DOE/RL-92-76).

***Uranium responded more slowly than technetium-99 to the pump-and-treat system. All uranium concentrations were below the remedial action goal (480 µg/L), but most were above the drinking water standard (30 µg/L) within the pump-and-treat area.***

An interim remedial action pump-and-treat system operated in the central part of the 216-U-1/2 Cribs plume from 1994 until the initiation of a rebound study in early 2005. Groundwater extraction resumed in April 2007 following the rebound study. The current remedial action goal (480 µg/L) is ten times the WAC 173-340 level at the time the interim record of decision was issued (EPA/ROD/R10-97/048, *Declaration of the Record of Decision for the 200-UP-1 Operable Unit*), which was 48 µg/L. This cleanup level has been revised to 30 µg/L (the drinking water standard), and it is expected that the remedial action goal will be revised to 300 µg/L. The pump-and-treat remediation effort has been successful in reducing uranium concentrations below the current remedial action goal of 480 µg/L, and with the exception of well 299-W19-37, concentrations at all wells in the pump-and-treat area are below 300 µg/L. However, concentrations at most wells continue to exceed

the drinking water standard of 30 μg/L. Uranium was reported at 322 μg/L for the one sample collected at well 299-W19-37 during FY 2008. During FY 2007, the uranium concentration in extraction well 299-W19-36 had increased to 613 μg/L, just prior to the restart of pumping. The concentration has since declined in response to pumping, and was below 300 μg/L during FY 2008.

Near the source of the 216-U-1/2 Cribs plume, uranium continues to be elevated in well 299-W19-18, although the concentration has decreased since 2004 (Figure 2.9-6). During FY 2008, the average uranium concentration was 370 μg/L, down from the average FY 2007 concentration of 410 μg/L. The small change in uranium concentration in this well over the past 10 years may be due to an ongoing source of uranium to the aquifer water. One possible source is continued leaching from the vadose zone beneath the 216-U-1/2 Cribs. However, the uranium concentration may be a consequence of the slow migration of this constituent compared to technetium-99.

Maps of depth-discrete sampling results for uranium during well installation between FY 2003 and FY 2006 were presented in the FY 2006 annual report (PNNL-16346). Uranium was found above the drinking water standard only in the 216-U-1/2 Cribs plume, and the data indicated that the plume is limited to the upper ~20 m of the aquifer. There were no exceedances of the drinking water standard below 20 m depth. Even in those wells (299-W19-46, 299-W19-49, and 699-38-70B) in which technetium-99 was found above the drinking water standard relatively deep in the aquifer, uranium was not elevated at the same depths. Uranium was not detected above the drinking water standard in the southern part of the 200 West Area; all measured uranium concentrations were less than 5 μg/L. Depth discrete sampling for uranium was not performed in the new wells installed during FY 2008.

### 2.9.1.3 Tritium

Disposal facilities associated with the REDOX Plant are the primary sources of tritium in the 200-UP-1 groundwater interest area, although U Plant disposal sites were another source of tritium. The REDOX Plant operated from 1952 until 1967, although effluent releases continued to occur after that time. A large tritium plume from the REDOX Plant cribs originates from the southern part of the 200 West Area and extends ~5 km toward the east and northeast at levels above the 20,000 pCi/L drinking water standard. Two high concentration areas occur within this region; a large plume extending to the east and northeast from the 200 West Area and a smaller plume extending ~550 m to the east-southeast from the 216-S-25 Crib (Figure 2.9-7).

***The tritium plume originating from the southern part of the 200 West Area is attenuating through dispersion and radiological decay.***

Measured concentrations in the eastern high concentration area range from ~160,000 to 1 million pCi/L. Concentrations are generally declining at six wells and increasing at three, indicating that the plume has localized areas of high concentrations. When these areas pass by wells, increasing concentrations can occur. However, the plume exhibits declining concentrations overall and the areal extent, as defined by the 2,000-pCi/L contour, has changed little, indicating natural attenuation by dispersion and radiological decay.

Tritium occurs above the drinking water standard in eight wells downgradient of the 216-S-25 Crib. Historical concentrations fluctuated in a single well (299-W23-9) on the downgradient side of the crib, but this well has gone dry and can no longer be sampled. Farther downgradient, trends are declining or stable in all but one well (299-W23-21), which shows an increasing trend. Radioactive liquid effluent

was disposed to this crib from 1973 through 1980, and in 1985, effluent from a pump-and-treat system at the 216-U-1/2 Cribs was disposed to this crib. In the vadose zone beneath this crib, tritium in the residual soil moisture may be migrating slowly to the water table, which would account for the fluctuating tritium concentration trend in well 299-W23-9. The plume has migrated under WMA S-SX, but the tank farms are not considered a direct source of tritium to the groundwater. Tritiated water in the tanks was removed and disposed of at the 216-S-25 Crib. The maximum concentration measured in this plume during FY 2008 was 110,000 pCi/L in well 299-W23-21, which is upgradient of WMA S-SX.

The tritium concentration in groundwater near the 216-S-21 Crib (west of WMA S-SX) continued to increase during FY 2008, reaching 30,000 pCi/L in well 299-W23-4 during March 2008 (Figure 2.9-8). This crib has been a major source of tritium in the past; the peak tritium concentration in well 299-W23-4 occurred in 1963 and 1964 at 110 million pCi/L.

### 2.9.1.4 Iodine-129

Iodine-129 plumes in the 200-UP-1 groundwater interest area originate from both U Plant and REDOX Plant disposal facilities (Figure 2.9-9). One plume originates from the 216-U-1/2 Cribs, while another originates from the southern part of the 200 West Area. At the current level of monitoring detail, these plumes merge downgradient and become indistinguishable. This combined plume (as defined by the 1 pCi/L contour level) extends to the east a total distance of ~3.5 km. Measured concentrations near the REDOX Plant cribs (southern 200 West Area) are above the drinking water standard (1 pCi/L); well 299-W22-72 had an average concentration of 2.2 pCi/L during FY 2008.

***A high concentration portion of the iodine-129 plume is migrating to the east out of the 200 West Area into the 600 Area.***

Groundwater sampling results near the 216-U-1/2 Cribs, 216-U-17 Crib, and the 216-S-9 Crib are flagged as not detected (Figure 2.9-9) but are believed to represent valid approximations of the iodine-129 concentration in the aquifer. The analytical laboratory is conservative, by requiring confirmation through the presence of a secondary (less sensitive) energy peak, prior to considering the iodine-129 detected (Section 1.8). In the late 1980s, shortly after the large uranium release to the aquifer beneath the 216-U-1/2 Cribs, iodine-129 was detected at ~30 pCi/L. Iodine-129 was detected at ~9 pCi/L in 2000 in a single well just before it went dry (well 299-W19-3). Thus, these cribs were a source of iodine-129, and it is reasonable to conclude that the vadose zone beneath these cribs contains residual iodine-129 that may be currently leaching into the aquifer and migrating toward the U Plant vicinity. The same may be true for the 216-S-9 Crib, although there are no historical sample results for iodine-129 in the vicinity of this crib.

A high concentration part of the iodine-129 plume has migrated to the east out of the 200 West Area into the surrounding 600 Area. Measured concentrations in the central part of this plume typically reach up to ~30 pCi/L. Concentrations are generally declining or stable throughout the plume, and dispersion is slowly reducing the plume size (i.e., the region of the plume above the drinking water standard). Radiological decay is not a factor in the declining areal extent, because iodine-129 has a long half-life (15.7 million years).

Iodine-129 sampling results during FY 2008 were consistent with past plume interpretations, including the results at the new monitoring wells. The maximum measured concentration within the interest area during FY 2008 was 37 pCi/L in well 699-35-70.

### 2.9.1.5 Nitrate

*Nitrate originates from multiple sources in the 200-UP-1 groundwater interest area and occurs in a large plume extending ~4 km to the east-northeast.*

Nitrate plumes in the 200-UP-1 groundwater interest area are thought to have originated from both the U Plant and REDOX Plant disposal facilities and are widespread throughout the area. Potential sources of nitrate from U Plant include the 216-U-1/2; 216-U-8; 216-U-12; 216-U-16; and 216-U-17 Cribs. Potential sources from REDOX Plant sites include the 216-S-1/2 and 216-S-25 Cribs. The nitrate plumes from these and other sources merge downgradient into a single large plume, which extends to the east and northeast a total distance of ~4 km (Figure 2.9-10). Nitrate sources from REDOX Plant disposal facilities also may have contributed to this plume. With a few exceptions, concentrations throughout the large plume outside the 200 West Area are stable or declining. On the eastern margin of the plume, concentrations are stable in well 699-36-61A, increasing in well 699-40-62, and are declining in well 699-44-64.

*Nitrate concentrations at most of the 200-UP-1 pump-and-treat wells are generally stable or declining in response to the restart of groundwater extraction in April 2007.*

Within the pump-and-treat area near the 216-U-17 Crib, nitrate concentrations declined in extraction well 299-W19-43 during FY 2008, in response to the resumption of groundwater pumping in April 2007. The average concentration in this well during FY 2006 was ~1,600 mg/L, but the concentration declined to 700 mg/L during March 2008. This decline is probably the result of the reduction of contaminant mass in the aquifer combined with the growth of the capture zone. As the capture zone grows in response to pumping, water having a lower nitrate concentration, quite possibly from beneath the plume, may be drawing into the extraction well and diluting the water of higher nitrate concentration. At the other extraction well (299-W19-36), concentrations were generally stable during FY 2008, ranging from 280 to 300 mg/L. Nitrate concentrations were increasing in observation well 299-W19-37 prior to the resumption of groundwater extraction, but this trend reversed once pumping began. The concentration in this well peaked at 630 mg/L in April 2007, but has now declined to 200 mg/L in March 2008. The maximum nitrate concentration values seen in these wells are higher than concentrations measured historically at the 216-U-1/2 Cribs in the 1970s and 1980s (~100 to ~300 mg/L). It appears that nitrate may have a local source in the vicinity of the pump-and-treat area.

The occurrence of nitrate above the drinking water standard deep in the unconfined aquifer does not appear to be widespread. The nitrate distribution depicted in Figure 2.9-10 represents nitrate concentrations in the upper portion of the unconfined aquifer, since most of the wells are screened across the water table. Of the wells actively sampled within the interest area, seven are screened deeper in the aquifer and five of these are within the mapped nitrate plume. In only one of these deeper wells (699-38-70C), is nitrate found at levels above the 45 mg/L drinking water standard. The concentration trend in this well is stable (~160 mg/L).

WMA U is a source of nitrate to groundwater (Section 2.9.3.1). Nitrate concentrations in three of the downgradient wells were above the drinking water standard during FY 2008. The maximum measured nitrate concentration at the U Tank Farm during FY 2008 was 88 mg/L in well 299-W19-44.

Nitrate occurs in two small plumes associated with REDOX Plant disposal facilities: one near the 216-S-20 Crib and another near the 216-S-25 Crib. Well 299-W22-20 (downgradient of the 216-S-20 Crib) had a nitrate concentration of 104 mg/L for September 2007. The concentration in this well has been declining since a maximum value occurred in December 2005 at 144 mg/L. At new well 699-34-72 (located about 320 m downgradient from the 216-S-20 Crib), the average nitrate concentration

was 32 mg/L during FY 2008. From 1952 through 1972, this crib received waste from laboratory hoods and decontamination sinks in the 222-S Building, along with laboratory waste from the 300 Area.

The nitrate plume originating from the 216-S-25 Crib merges with the southern nitrate plume from WMA S-SX (Section 2.9.3.2). Nitrate concentrations from the tank farm correlate with technetium-99 concentrations. In well 299-W23-19 at the southwest corner of WMA S-SX, the nitrate concentration was generally stable during FY 2008 (coincident with the technetium-99 and chromium trend) (~370 mg/L).

### 2.9.1.6 Chlorinated Hydrocarbons

Carbon tetrachloride occurs above the drinking water standard (5 μg/L) in numerous wells within the 200-UP-1 groundwater interest area. At the water table, the plume is widespread in the south 200 West Area, and extends ~1 km east into the 600 Area (Figure 2.8-3). The plume originated from waste disposal sites associated with the Plutonium Finishing Plant in the 200-ZP-1 groundwater interest area. Concentration trends are increasing in ten wells, decreasing in eight wells, and fluctuating but generally stable in numerous wells. No clear spatial pattern is evident among wells having increasing or decreasing trends.

***The carbon tetrachloride plume within the 200-UP-1 groundwater interest area was interpreted to be further to the south than in previous years, based on the sample results of newly installed monitoring wells.***

Within the pump-and-treat area, carbon tetrachloride concentrations at all wells exceeded the 5 μg/L drinking water standard. During FY 2008, well 299-W19-49 showed the greatest increase in the concentration of carbon tetrachloride within the pump-and-treat area: 240 μg/L in the second quarter increasing to 410 μg/L in the fourth quarter. Other wells showing increasing concentration trends included wells 299-W19-36 and 299-W19-101. From FY 2007 to FY 2008, wells 699-38-70B and 299-W19-48 showed the greatest decreases in concentration. Historically, wells 699-38-70B and 299-W19-36 have shown the highest concentrations and greatest quarterly sampling variability.

Figure 2.9-11 shows depth-discrete sampling results for carbon tetrachloride in three of the new wells. Past depth-discrete sampling in the eastern part of the plume has shown that concentrations generally increase with depth to the Ringold Formation lower mud unit. The occurrence of this constituent at depth has been attributed to carbon tetrachloride density, artificial and natural recharge, and changes in groundwater flow directions (DOE/RL-2006-24). This concentration increase with depth was observed in depth discrete groundwater samples collected from well 299-W22-88 during drilling. The peak carbon tetrachloride concentration was 22 μg/L at 38 m below the water table, compared to 3.6 μg/L in the upper part of the aquifer. High concentrations of carbon tetrachloride also were found in new well 699-33-75 at the 216-S-10 Pond and Ditch. Here, the peak concentration was 43 μg/L at 13 m below the water table. At new well 699-33-74 (~300 m south of REDOX Plant), carbon tetrachloride was measured at 24 and 20 μg/L in samples collected from the completed well during May and August 2008, respectively, although the peak concentration measured during drilling was 6 μg/L. The carbon tetrachloride plume is now interpreted to be farther south than in previous annual reports, based on the sample results from wells 699-33-74 and 699-33-75.

***Depth-discrete sampling during well installation shows that carbon tetrachloride, chloroform, and trichloroethene concentrations generally increase with depth in the eastern part of the operable unit.***

The highest carbon tetrachloride concentration measured during FY 2008 was 1,400 μg/L in well 299-W14-71, which is screened from 40.9 to 45.4 m below the water table just above the Ringold Formation lower mud unit. Section 2.8 provides more information regarding carbon tetrachloride in the 200 West Area.

Chloroform is a degradation product of carbon tetrachloride and tends to occur in the same wells with carbon tetrachloride. Thus, some degradation of carbon tetrachloride may be occurring, although chloroform could have been introduced to the aquifer from the 2607-Z Tile Field (Section 2.8). A total of 137 chloroform analyses were performed on samples from 53 wells within the 200-UP-1 groundwater interest area, and no exceedances of the drinking water standard (80 μg/L) were observed in FY 2008. The maximum concentration measured during FY 2008 was 17 μg/L in well 299-W14-71. Depth-discrete sampling during new well installation has shown that concentrations tend to increase with depth, similar to carbon tetrachloride.

Trichloroethene is found within the 200-UP-1 groundwater interest area above the drinking water standard (5 μg/L) in the vicinity of the pump-and-treat system, as well as to the north at well 299-W14-71. Depth-discrete sampling results show that concentrations tend to increase with depth. A total of 154 trichloroethene analyses were performed on samples from 53 wells within the interest area, and the drinking water standard was exceeded in three wells during FY 2008 (299-W14-71, 699-38-70B, and 699-38-70C). All of these wells are screened deep within the unconfined aquifer just above the Ringold Formation lower mud unit. In previous years, trichloroethene had been detected in well 299-W19-34B above the drinking water standard, but the concentration was below the standard during FY 2008. Concentrations are generally stable in wells 699-38-70B and 699-38-70C, fluctuating in 299-W19-34B, and declining in 299-W14-71. There were no exceedances of the drinking water standard in wells monitoring the upper part of the aquifer near the water table. The maximum concentration measured was 9.6 μg/L in well 299-W14-71. The areal extent of trichloroethene does not coincide with the distribution of carbon tetrachloride, which suggests a localized source in the U Plant area.

### 2.9.1.7 Strontium-90

Strontium-90 in groundwater occurs in only one location within the interest area: at well 299-W22-10 downgradient from the 216-S-1/2 Cribs. This well was last sampled in FY 2006, and the result was 27 pCi/L, which was above the drinking water standard (8 pCi/L). The 216-S-1/2 Cribs received highly acidic waste from the REDOX Plant between 1952 and 1956. In 1955, the waste is believed to have corroded the casing of a nearby well 299-W22-3 (not shown in Figure 2.9-1, but this well is located at the 216-S-1/2 Cribs), which allowed the effluent to bypass the soil column and flow down the well directly into groundwater (Waste Information Data System). This is the postulated pathway by which strontium-90 may have reached groundwater at this location.

During FY 2008, 20 analyses for strontium-90 were performed on samples collected from ten wells within the groundwater interest area, but there were no strontium-90 detections.

***In well 299-W23-19 at Waste Management Area S-SX, chromium concentrations were generally stable during FY 2008 at an average value of 730 μg/L.***

### 2.9.1.8 Chromium

High concentrations of dissolved chromium (i.e., total chromium in filtered samples) are found in two regions of the 200-UP-1 groundwater interest area: at WMA S-SX and in the 600 Area east and southeast of the 200 West Area. During FY 2008, samples from four wells in WMA S-SX exceeded the drinking water standard (100 μg/L). The highest concentrations occurred at well 299-W23-19 (averaging 730 μg/L for filtered samples and 735 μg/L for unfiltered samples), where

the dissolved chromium trend was relatively stable during FY 2008 (Figure 2.9-4). This well is near the source of a chromium, technetium-99, and nitrate plume originating from the SX Tank Farm.

A second plume occurs in the northern part of WMA S-SX, downgradient from the S Tank Farm. At well 299-W22-44, the dissolved chromium concentration had increased during FY 2007 from 74 μg/L during October 2006 to 345 μg/L during September 2007. The dissolved concentration peaked at 630 μg/L during June 2008, then declined to 540 μg/L during September 2008 (620 and 550 μg/L for unfiltered samples, respectively). The other mobile tank waste constituents (technetium-99 and nitrate) also have increased substantially during this time. In general, chromium concentrations are increasing at WMA S-SX and the areal extent of both the northern and southern plumes is growing. Section 2.9.3.2 provides more information on chromium in WMA S-SX.

Chromium is frequently detected in wells east and southeast of the 200 West Area. An interpretation of the chromium extent in this area is shown in the summary of this report. The dissolved chromium concentration in well 699-32-62 was 152 μg/L in September 2007, little changed from the previous sampling two years earlier. Chromium concentrations have declined slowly since this constituent was first analyzed at this well in 1992, and the next scheduled sampling is in March 2009. Dissolved chromium also is elevated at well 699-30-66 (102 μg/L in February 2006), which is completed deep in the aquifer just above the lower mud unit. This indicates that chromium may occur throughout the aquifer thickness in the region. The sources and extent of the contamination are uncertain. The location of this plume is consistent with disposal to the REDOX Plant ponds/ditches south and southwest of the 200 West Area. Chromium is detected in several other wells in this area, but its extent to the south is not well defined.

Dissolved chromium was formerly detected above the drinking water standard in well 299-W22-20 at the 216-S-20 Crib. This well is now dry and can no longer be sampled. Well 299-W22-20 was last sampled for chromium in August 2006, and the result was 10 μg/L, even though the previous two sample results were greater than 200 μg/L. It was suspected that the August 2006 sample result was not representative of the aquifer because of reducing conditions in the well (DOE/RL-2008-01).

Both filtered and unfiltered samples were collected for metals analysis during FY 2008, and some concentration differences between the filtered and unfiltered results were observed for chromium. Where chromium concentrations were near detection limits, concentrations in the unfiltered samples tended to be higher than in the filtered samples. For example, in the February 2008 sample from well 299-W18-22, chromium was not detected in the filtered sample (4 μg/L detection limit), while the unfiltered result was 13.4 μg/L, and in the November 2007 sample from well 299-W19-101, chromium also was not detected in the filtered sample (4 μg/L detection limit), while the unfiltered result was 33.7 μg/L. However, at higher chromium concentrations, there was no substantial difference between the filtered and unfiltered results. At well 299-W23-19, the largest difference between a filtered and unfiltered chromium result was 10 μg/L for the January 2008 sample (744 μg/L filtered, 754 μg/L unfiltered), which yielded a relative percent difference of less than 2 percent.

### 2.9.1.9 Other Constituents

Arsenic and cadmium are listed as contaminants of concern for the 200-UP-1 Operable Unit (DOE/RL-92-76). During FY 2008, 50 analyses were performed for arsenic in 23 wells and 168 analyses were done for cadmium in 52 wells. No confirmed detections above a drinking water standard (10 μg/L for arsenic and 5 μg/L for cadmium) were observed in both the filtered and unfiltered samples.

The contaminants of concern for the 200-UP-1 Operable Unit have been classified into an initial list of high priority constituents (i.e., strontium-90, iodine-129, technetium-99, uranium, tritium, carbon tetrachloride, chloroform, trichloroethene, chromium, arsenic, cadmium, and nitrate) to support integrated CERCLA and AEA long-term monitoring, as well as additional contaminants of concern specifically identified to support the remedial investigation/feasibility study (DOE/RL-92-76). These additional contaminants of concern are documented in the remedial investigation/feasibility study work plan (DOE/RL-92-76) and include an extended list of volatile organic compounds, metals, anions, ammonium ion, ammonia, cyanide, sulfide, cresols, phenols, total petroleum hydrocarbons (kerosene range), beta emitters (carbon-14 and selenium-79), alpha emitters (neptunium-237 and protactinium-231), and gamma emitters (cesium-137 and cobalt-60).

Wells 299-W19-105, 299-W19-107, 299-W22-69, 299-W22-72, 299-W22-86, 299-W22-87, as well as five of the new wells (299-W22-88, 699-32-76, 699-33-74, 699-33-75, and 699-34-72), were specifically sampled for the additional contaminants of concern during FY 2008. Other than those constituents that are naturally present in groundwater (e.g., magnesium, manganese, vanadium, etc.), only two constituents were persistently detected in a monitoring well (carbon-14 in well 299-W22-72 and selenium-79 in well 299-W22-86). Carbon-14 was detected in four samples collected from well 299-W22-72, but at levels far below the drinking water standard. The maximum concentration was 33 pCi/L, and the drinking water standard is 2,000 pCi/L. In addition, carbon-14 was detected in one sample from new well 699-34-72 (located outside the southeast corner of the 200 West Area). The concentration was 12 pCi/L. Selenium-79 was detected in two of three samples collected from 299-W22-86, at 22 and 26 pCi/L. There is no established drinking water standard for selenium-79, but the DOE established the derived concentration guide of 20,000 pCi/L (100 mrem/yr effective dose equivalent). The concentration corresponding to a 4 mrem/yr effective dose equivalent (DOE drinking water systems criterion) is 800 pCi/L. The reported concentrations at well 299-W22-86 are well below these values. Other additional constituents of concern were sporadically detected in one or more wells at low levels (ammonium ion, cobalt, cyanide, iron, lead, mercury, and neptunium-237). Additional sampling did not confirm any of these detections, and they are suspected of being false positive results.

Additional sampling for selenium-79 was conducted during September 2008 in all the monitoring wells routinely sampled for WMA S-SX. This constituent was reported above detection limits in five of nineteen wells, with concentrations ranging from 17 to 285 pCi/L. All of these detections are below the 4 mrem/yr effective dose equivalent of 800 pCi/L.

## 2.9.2 Operable Unit Activities

### *G. G. Kelty*

This section describes activities related specifically to the 200-UP-1 Operable Unit. These activities involve the interim action pump-and-treat system operating near the 216-U-17 Crib and responses to the second CERCLA five-year review. The sampling and analysis plan for FY 2008 sampling of the operable unit is incorporated into the remedial investigation/feasibility study work plan for the 200-UP-1 Operable Unit (DOE/RL-92-76). This plan integrates CERCLA and AEA monitoring, and is a revision of the original integrated plan issued during June 2002 (DOE/RL-2002-10, *Sampling and Analysis Plan for the 200-UP-1 Groundwater Monitoring Well Network*). Appendix A presents the monitoring information for the 200-UP-1 Operable Unit, including a well list, sampling frequency, and a list of analytes.

Fifty-three wells were scheduled for sampling during the fiscal year, and fifty were sampled successfully. Well 299-W19-39 is a former pump-and-treat extraction well that cannot be sampled because of a pump problem, and wells 299-W23-9 and 699-38-70 went dry. Six groundwater monitoring wells (299-W22-88, 699-32-76, 699-33-74, 699-33-75, 699-33-76, and 699-34-72) were installed for the 200-UP-1 Operable Unit during FY 2008. These wells fulfill the need for additional spatially distributed groundwater data and to complete the remedial investigation. Depth and monitoring requirements were identified in the remedial investigation/ feasibility study work plan for the 200-UP-1 Operable Unit (DOE/RL-92-76). Well installations began in February 2008 and were completed by May 2008.

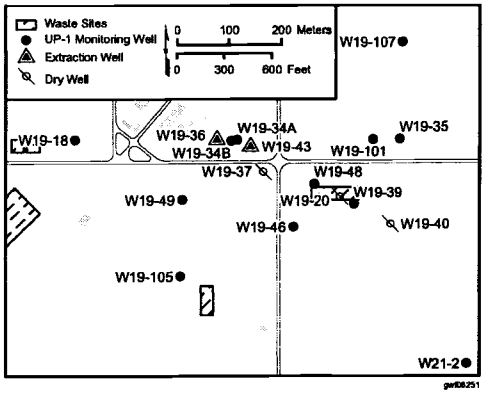
### 2.9.2.1 Status of Five-Year Review Action Items

The second CERCLA five-year review for all Hanford Site CERCLA units was published in November 2006 (DOE/RL-2006-20). One issue and associated action was identified for the 200-UP-1 Operable Unit.

- **Issue 18.** The remedial action objective for uranium was based on the Washington State WAC 173-340 cleanup standard of 48 μg/L. Since this time, the U.S. Environmental Protection Agency (EPA) has established a drinking water standard of 30 μg/L. There are some other issues to be addressed within the record of decision, including the limited quarterly pumping requirement at well 299-W23-19, adjusting the pumping requirement for the 200-UP-1 Operable Unit because of limited flow within the extraction well network, and technetium-99 groundwater contamination at other locations within the operable unit.
- **Action 18-1.** Prepare an explanation of significant difference for 200-UP-1 Operable Unit interim action record of decision (not completed during FY 2008).
- **Response.** The explanation of significant difference is being prepared by the Washington State Department of Ecology (Ecology), which is currently collaborating with the DOE for specific content of the document.

***The 200-UP-1 Pump-and-Treat System extracted 13.5 million liters from the aquifer during FY 2008.***

### 2.9.2.2 Interim Groundwater Remediation for Technetium-99 and Uranium




Extraction wells 299-W19-36 and 299-W19-43 were restarted on April 19, 2007, following a 1-year rebound study and 15 months on hot standby, during which the wells were maintained in a condition allowing for a quick restart. The system remained in operation until August 6, 2008, at which time it was shutdown while the Effluent Treatment Facility conducted facility upgrades. During operation, groundwater was pumped to the Liquid Effluent Retention Facility for eventual transfer to the Effluent Treatment Facility for removal of uranium, along with technetium-99, carbon tetrachloride and nitrate. During FY 2008, uranium concentrations at the 12 wells surrounding the original baseline uranium plume did not exceed the current 480 µg/L remedial action goal established by the interim record of decision (EPA/ROD/R10-97/048).

**Progress During FY 2008.** Extraction wells 299-W19-36 and 299-W19-43 operated sporadically during FY 2008 because of pump problems and scheduled Liquid Effluent Retention Facility process and maintenance activities. Well 299-W19-36 was on-line 294 days and discharged a total of 8.4 million liters at a pumping rate of 20 L/min. Well 299-W19-43 was on-line 195 days and discharged a total of 5.1 million liters at a pumping rate of 18 L/min. This resulted in a total combined volume of 13.5 million liters of groundwater discharged to basin 43 at the Liquid Effluent Retention Facility. An estimated 3.5 kg of uranium, 4.6 g of technetium-99, 3.0 kg of carbon tetrachloride, and 6,380 kg of nitrate were discharged to basin 43 (Table 2.9-1). Over 869 million liters have been treated since startup of remediation activities in FY 1994. A total of 216 kg of uranium, 124 g of technetium-99, 37.7 kg of carbon tetrachloride, and 41,500 kg of nitrate have been removed from the effluent during treatment. Prior to operation of the pump-and-treat system, the baseline plume was estimated to contain a total mass of 0.16 kg technetium-99 and 130 kg of uranium (DOE/RL-97-36, *200-UP-1 Groundwater Remedial Design/ Remedial Action Work Plan*). Thus, ~78% of the original technetium-99 mass has been recovered, while more uranium has been recovered than was originally estimated to be present.

***The interim remedial action objectives for the 200-UP-1 Operable Unit (EPA/ROD/R10-97/048) are as follows.***

- ***Reduce contamination in the areas with the highest concentration to below 480 µg/L for uranium and 9,000 pCi/L for technetium-99.***
- ***Reduce potential adverse human health risks through reduction of contaminant mass.***
- ***Prevent further movement of these contaminants from the highest contamination area.***
- ***Provide information that will lead to the development and implementation of a final remedy that will protect human health and the environment.***

Hydraulic head trends at several groundwater wells within the 200-UP-1 Operable Unit baseline plume area were used to determine the decline in groundwater elevations. Within the baseline plume area, the water table declined at an average rate of 0.21 m/yr in FY 2008. This is less than the 0.31 m/yr rate for FY 2007, but about the same as the 0.23 m/yr rate in FY 2005 and FY 2006.

**Influence on Aquifer Conditions.** Figures 2.9-12 and 2.9-13 show the technetium-99 and uranium plumes for the upper unconfined aquifer at the pump-and-treat area, based on average concentrations for FY 2008. Maps depicting the baseline technetium-99 and uranium plumes in 1995 and the current plumes in FY 2008 are presented in the Summary.

Uranium concentrations remained below the current remedial action goal of 480 µg/L for the baseline plume monitoring wells during FY 2008. Well 299-W19-35 was the only well showing an increasing trend in FY 2008. The maximum quarterly sample result for this well was 68.2 µg/L, which is well below the current and proposed remedial action goals of 480 and 300 µg/L, respectively. Uranium trends remained stable or were decreasing at all other wells, including extraction well 299-W19-36. This well had a short-lived spike exceeding the current remedial action goal occurred in FY 2007, prior to restart of the extraction system (Figure 2.9-14). The elevated uranium concentrations were observed at extraction wells 299-W19-36 (263 µg/L) and 299-W19-43 (288 µg/L), and monitoring wells 299-W19-37 (322 µg/L) and 299-W19-18 (391 µg/L) (Figure 2.9-14). The maximum FY 2008 uranium concentration within the baseline plume area occurred at well 299-W19-18, located approximately 80 m (263 ft) downgradient of the 216-U-1/2 Cribs. This well continues to show a decreasing trend, with an average annual concentration of 416 µg/L in FY 2007 and 370 µg/L in FY 2008 (Figure 2.9-6).

***Uranium and technetium-99 concentrations at the 200-UP-1 pump-and-treat area were below their respective remedial action goals throughout FY 2008.***

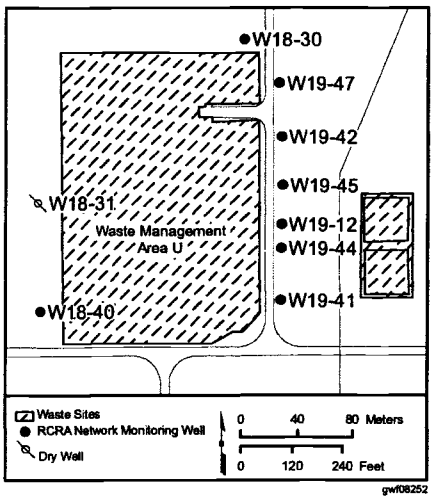
Technetium-99 concentrations were substantially below the 9,000 pCi/L remedial action goal for all monitoring and extraction wells, with the exception of the first quarter results for extraction well 299-W19-36 (Figure 2.9-15). Concentrations have declined in this well from 11,000 pCi/L in October 2007 to 6,500 pCi/L in May 2008, with an average annual value of 7,033 pCi/L for FY 2008. Wells 299-W19-18, 299-W19-107, 299-W19-105, and 299-W19-49 showed small increasing concentration trends and had slightly higher FY 2008 average concentrations compared to FY 2007.

## 2.9.3 Facility Monitoring

This section describes the results of monitoring individual waste management or disposal facilities. Some of these facilities are monitored under RCRA requirements for hazardous waste constituents and AEA for source, special nuclear, and by-product materials. Data from facility-specific monitoring also are integrated into the CERCLA groundwater investigations. Hazardous constituents and radionuclides are discussed jointly in this section to provide comprehensive interpretations of groundwater contamination for each facility. As discussed in Section 1.2 pursuant to RCRA, the source, special nuclear, and by-product material component of radioactive mixed waste are not regulated under RCRA and are regulated by the DOE acting pursuant to its AEA authority.

Detailed groundwater monitoring is conducted at four facilities within the 200-UP-1 Operable Unit. Three of these sites were monitored in accordance with RCRA regulations. Assessment monitoring in response to apparent releases impacting groundwater was conducted at WMAs U and S-SX, and detection monitoring was conducted at the 216-S-10 Pond and Ditch. RCRA assessment monitoring was formerly conducted at the 216-U-12 Crib, but the status of that site was changed from a RCRA treatment, storage, and/or disposal site to a RCRA past-practice site during FY 2007 in change requests B-05-01 and C-05-01 of the Tri-Party Agreement (Ecology et al., 1989). FY 2007 was the last year of RCRA assessment monitoring at that site. Groundwater monitoring at the ERDF is conducted in accordance with a CERCLA record of decision (EPA/ROD/R10-95/114). Groundwater data for these facilities are available from the Hanford Environmental Information System database and the data files accompanying this report.

### 2.9.3.1 Single-Shell Tank WMA U




The objective of RCRA monitoring at this WMA is to assess the nature and extent of groundwater contamination with hazardous constituents and determine their rate of movement in the aquifer (40 CFR 265.93(d) as referenced by WAC 73-303-400). Groundwater monitoring under the AEA tracks radionuclides in the WMA and surrounding area. Appendix B includes a well location map and lists of wells and constituents monitored for WMA U.

WMA U was placed into assessment status in 2000 when specific conductance in groundwater monitoring wells downgradient of the WMA exceeded upgradient levels (PNNL-13185, *Groundwater Quality Assessment Plan for Single-Shell Tank Waste Management Area U at the Hanford Site*). An assessment of that finding determined that the WMA had affected groundwater quality based on elevated concentrations of nitrate and possibly chromium in wells downgradient of the WMA (PNNL-13282). Contaminant concentrations did not exceed their respective drinking water standards, and the affected area appeared to be limited to the southeast corner of the WMA. Groundwater quality is assessed at WMA U according to PNNL-13612-ICN-2, *Groundwater Quality Assessment Plan for Single-Shell Tank Waste Management Area U*. The monitoring network consists of eight wells sampled quarterly: one upgradient and seven downgradient of the WMA (former upgradient well 299-W18-31 went dry during FY 2007). All eight monitoring wells were sampled as scheduled during FY 2008.

***Sources within Waste Management Area U have contaminated groundwater with nitrate and technetium-99.***

***Groundwater Flow.*** Groundwater flow conditions at WMA U have varied over the past several decades because of changing wastewater disposal in areas surrounding the WMA, but flow has been generally to the east since 1996 (~080° azimuth). During FY 2008, the water-table elevation declined at an average rate of 0.45 m/yr until May 2008. In response to the shutdown of the 200-ZP-1 Pump-and-Treat System extraction wells in late May (Section 2.8), the water-table elevation beneath the WMA increased by an average of 0.26 m between May and August 2008. Analysis of water-level data collected during March 2008 indicated the hydraulic gradient is $2.1 \times 10^{-3}$, and the groundwater flow rate (i.e., average linear velocity) ranges from 0.018 to 0.20 m/day (7 and 73 m/yr), depending on the hydraulic conductivity and effective porosity. Using values believed to be most representative, 6.12 m/day for the hydraulic conductivity and 0.17 for the effective porosity from a constant-rate pumping test conducted in well 299-W19-42 (PNNL-13378), the groundwater flow rate most representative for this site is 0.076 m/day (28 m/yr).

***Technetium-99 concentrations are higher in the northern wells at Waste Management Area U while nitrate concentrations are higher in the southern wells.***

***Groundwater Contamination.*** WMA U has been identified as the source of groundwater contamination limited to the downgradient (east) side of the site (PNNL-13282). Constituents found in the groundwater originally included chromium, nitrate, and technetium-99, but chromium concentrations decreased in the past to near the analytical detection limit, where they remained in FY 2008. Nitrate and technetium-99 appear to have different sources within the WMA, because nitrate concentrations are highest along the southern half of the site and technetium-99 concentrations are highest along the northern half (Figure 2.9-16). These constituents are both mobile in groundwater and would be expected to travel together if they were from the same source.

During FY 2008, measured technetium-99 concentrations exceeded the drinking water standard (900 pCi/L) in at least one sample from each well along the north

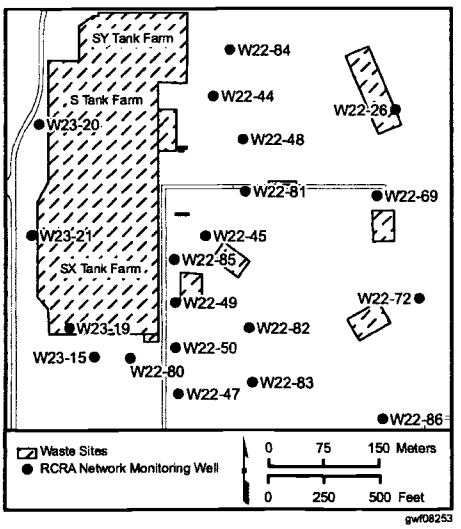
downgradient side of the WMA (299-W18-30, 299-W19-42, 299-W19-45, and 299-W19-47). The maximum technetium-99 concentration measured in a quarterly sample was 1,900 pCi/L in well 299-W19-47 during May and August 2008. Concentrations are generally increasing at wells 299-W18-30, 299-W19-42, and 299-W19-47. At well 299-W19-45, the concentration had been decreasing in previous years, but was generally stable during FY 2008 at 1,000 to 1,200 pCi/L.

Nitrate concentrations continued to increase in all but two monitoring wells (299-W19-41 and 299-W19-44) at WMA U, including the upgradient well. During FY 2008, nitrate concentrations were above the drinking water standard (45 mg/L) in at least one sample from downgradient wells 299-W19-12, 299-W19-41, 299-W19-44, and 299-W19-45. The maximum nitrate concentration measured in a quarterly sample was 88 mg/L in 299-W19-44 during November 2007. The concentration at well 299-W19-45 exceeded the drinking water standard for the first time, reaching a maximum value of 54 mg/L during August 2008. Concentrations at well 299-W19-41 declined to below the drinking water standard during FY 2007. Well 299-W19-44 also exhibits a declining nitrate trend, but concentrations are still above the drinking water standard (~73 mg/L during August 2008). Concentrations are higher in the downgradient wells compared to the upgradient well, confirming that the WMA is a source of nitrate to the aquifer. However, nitrate from an upgradient source also is affecting the groundwater quality. During FY 2008, the maximum concentration measured in upgradient well 299-W18-40 was 38 mg/L in August 2008.

Carbon tetrachloride is found in groundwater beneath WMA U at concentrations above its drinking water standard of 5 µg/L. Well 299-W18-30 is the only well in which samples are analyzed for carbon tetrachloride, and it contained a concentration of 145 µg/L in August 2008, about the same as in August 2007. The regional carbon tetrachloride distribution (Figure 2.8-3) indicates that the carbon tetrachloride found in the groundwater beneath WMA U originates from liquid waste disposal sites northwest of the WMA.

### 2.9.3.2 Single-Shell Tank Waste Management Area S-SX

The objective of RCRA monitoring at this WMA is to assess the nature and extent of groundwater contamination with hazardous constituents and determine their rate of movement in the aquifer. Groundwater monitoring under the AEA tracks radionuclides in the vicinity of the WMA. Appendix B includes a well location map and lists of wells and constituents monitored for WMA S-SX. The WMA was placed into assessment status (40 CFR 265.93(d) as referenced by WAC 173-303-400) in 1996, at the direction of Ecology, because of elevated specific conductance and technetium-99 (not regulated by RCRA) in downgradient monitoring wells. An assessment of the WMA determined (first determination) that multiple sources within the WMA had affected groundwater quality with elevated concentrations of nitrate, technetium-99, and chromium in wells downgradient of the WMA (PNNL-11810). Groundwater is monitored according to PNNL-12114-ICN-4, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area S-SX at the Hanford Site.*




The monitoring network at WMA S-SX consists of 19 wells (2 upgradient wells, 16 downgradient wells, and 1 well within the WMA). One additional well (299-W22-26), located downgradient from the S Tank Farm, was informally added to the network in March 2008. All the wells in the network are scheduled for quarterly sampling, and all but two wells were sampled as scheduled during FY 2008. The

second quarter sampling was missed at well 299-W22-45 and the fourth quarter sampling of well 299-W22-86 was delayed until October 21, 2008.

***Groundwater Flow.*** During FY 2007, the water-table elevation declined at an average rate of 0.26 m/yr in the monitoring wells, similar to the long-term rate of decline since 2004. Analysis of water-level data collected during March 2008 indicated the hydraulic gradient is 1.9 x $10^{-3}$ due east (090° azimuth), and the groundwater flow rate (i.e., average linear velocity) ranges from 0.012 to 0.30 m/day (5 and 108 m/yr), depending on the hydraulic conductivity and effective porosity. Using values of 6.1 m/day for the hydraulic conductivity and 0.12 for the effective porosity (average values from multiple constant-rate pumping tests in wells at the WMA [PNNL-13514; PNNL-14113; PNNL-14186]), the groundwater flow rate most representative for this site is 0.094 m/day (34 m/yr). This is consistent with prior estimates of 0.07 to 0.14 m/day (25 to 50 m/yr) based on the movement of tritium between wells (PNNL-12114; PNNL-13441).

***Concentrations of the mobile tank waste constituents nitrate, chromium, and technetium-99 increased downgradient from the S Tank Farm during FY 2008, but not as much as during FY 2007.***

***Groundwater Contamination.*** Groundwater beneath this WMA is contaminated with nitrate, chromium, and technetium-99 attributed to two general source areas within the WMA. One source area is in the S Tank Farm and the other is located to the south in the SX Tank Farm. Nitrate also has other sources in the vicinity, most notably the 216-S-25 Crib. Figures 2.9-17 through 2.9-19 show the nitrate, chromium, and technetium-99 plumes, including average concentrations for FY 2008. Carbon tetrachloride also is present in groundwater beneath the WMA (Figure 2.8-3), but the sources are waste sites in the vicinity of the Plutonium Finishing Plant (PNNL-13441). Although tritium is present beneath the WMA (Figure 2.9-7), its source is the 216-S-25 Crib, located just west (upgradient) of the SX Tank Farm (PNNL-13441).

***Nitrate, chromium, and technetium-99 concentrations in well 299-W23-19 within Waste Management Area S-SX were generally stable during FY 2008, but continued to be significantly higher than drinking water standards.***

In the northern plume downgradient from the S Tank Farm, concentrations of the mobile tank waste constituents nitrate, chromium, and technetium-99 had increased substantially in well 299-W22-44 during FY 2007. Concentrations of these constituents continued to increase, but appeared to stabilize or decline, at least temporarily, near the end of FY 2008 (Figure 2.9-20). Peak concentrations in this well during FY 2008 were 630 µg/L for dissolved chromium (620 µg/L unfiltered) and 208 mg/L for nitrate, both during June 2008, and 14,000 pCi/L for technetium-99 during March, June, and September 2008. The drinking water standards for these constituents are 100 µg/L for chromium, 45 mg/L for nitrate, and 900 pCi/L for technetium-99. Concentrations of these constituents also are increasing in well 299-W22-26, further downgradient from the S Tank Farm. During September 2008, nitrate and technetium-99 exceeded drinking water standards with concentrations of 66 mg/L and 4,200 pCi/L, respectively; however, dissolved chromium had a concentration below the drinking water standard (45 µg/L). Concentrations of these constituents in the upgradient well for the S Tank Farm (299-W23-20) were either not detected or were below the drinking water standards, indicating that the tank farm is the source. Tank S-104 is the only tank within the S Tank Farm known to have leaked. A surface electrical-resistivity survey conducted during FY 2006 indicated that a portion of the vadose zone plume beneath tank S-104 at the 2 to 5 ohmmeter level had apparently reached groundwater (RPP-RPT-30976, *Surface Geophysical Exploration of S Tank Farm at the Hanford Site*). This is the presumed source of the northern groundwater plume.

Groundwater beneath the SX Tank Farm in the southern portion of the WMA also is contaminated with nitrate, chromium, and technetium-99. These plumes extend from the source area near well 299-W23-19 toward the east-southeast about 300 to 500 m at levels above drinking water standards (Figures 2.9-17 through 2.9-19). There are low concentration areas depicted in these plumes around wells 299-W22-80 and 299-W23-15. An in-well tracer test at well 299-W22-80, as well as time-series sampling during extensive purging, has indicated that relatively clean water may be migrating into the bottom of the well, moving up the wellbore, and diluting plume concentrations in the upper part of the plume (PNNL-15070). A similar process is assumed to be occurring at well 299-W23-15. In the source area, concentrations of all three constituents were generally stable in well 299-W23-19 during FY 2008. The average concentrations for FY 2008 were 372 mg/L for nitrate, 730 µg/L for dissolved chromium (735 µg/L unfiltered), and 53,000 pCi/L for technetium-99 (Figure 2.9-4).

The southern nitrate and technetium-99 plumes (at concentrations below drinking water standards) are interpreted to extend further southeast toward new well 699-33-74 (located about 240 m south of the 200 West Area boundary). This well had FY 2008 average concentrations of 420 pCi/L for technetium-99 and 17 mg/L for nitrate. The presence of these constituents at this location is consistent with past groundwater flow directions and a source in the vicinity of WMA S-SX. In addition, the nitrate to technetium-99 ratio is consistent with mixing of plumes from WMA S-SX and the 216-S-25 Crib.

During CERCLA sampling of well 299-W22-86 (~350 m downgradient from the SX Tank Farm), selenium-79 was detected in two samples collected during January and March 2008, at 22 and 26 pCi/L, respectively. During September 2008, all the network wells were sampled for selenium-79. This constituent was reported above detection limits in 5 wells, with concentrations ranging from 17 to 285 pCi/L: 299-W23-19 (285 pCi/L), 299-W22-44 (69 pCi/L), 299-W22-47 (61 pCi/L), 299-W22-83 (48 pCi/L), and 299-W22-50 (17 pCi/L). There is no established drinking water standard for selenium-79, but the DOE has established the derived concentration guide at 20,000 pCi/L (100 mrem/yr effective dose equivalent). The concentration corresponding to a 4 mrem/yr effective dose equivalent (DOE drinking water system criterion) is 800 pCi/L. All of the wells that had detectable selenium-79 are near-field downgradient wells within either the northern plume (from the S Tank Farm) or the southern plume (from the SX Tank Farm). Selenium-79 was not detected in upgradient wells; the reported concentrations were less than zero. The sample results for selenium-79 correlated with the technetium-99 results, indicating that selenium-79 occurs in association with technetium-99 and the other tank waste constituents in groundwater. Sampling for selenium-79 will continue during FY 2009.

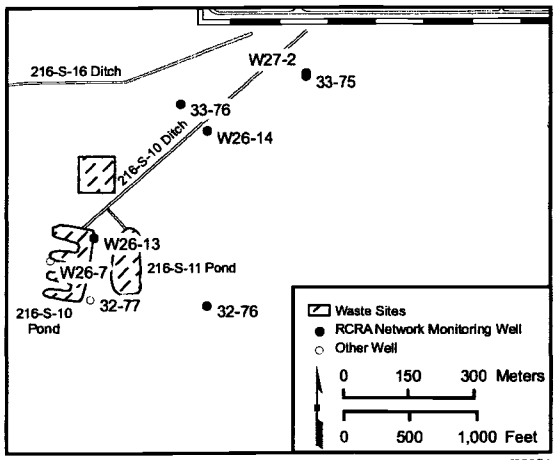
***Groundwater Treatment.*** The feasibility of using well 299-W23-19 as a pump-and-treat extraction well to remediate the southern plume from the SX Tank Farm was investigated in 2001. After performing an aquifer test in this well, it was concluded that the production capacity was too small for a pump-and-treat system (RPP-10757, *Subsurface Conditions Description of the U Waste Management Areas*). To remove some technetium-99 from the groundwater, the practice of extended purging during sampling at well 299-W23-19 was agreed to by the DOE and Ecology and began in 2003. After samples are collected from this well each quarter, purging

***In 2003, DOE and Ecology agreed to the practice of extended purging during sampling at well 299-W23-19 to remove technetium-99 from the groundwater. This practice continued during FY 2008.***

of the well is continued at a higher flow rate until a minimum of 3,785 L of water is removed from the aquifer. This water is transferred to the Effluent Treatment Facility for treatment and disposal. Table 2.9-2 presents the date, amount of water collected, and a calculation of the mass and activity of technetium-99 removed from the aquifer. A total of ~0.0011 Ci (~0.066 g) of technetium-99 was recovered during FY 2008. Since the start of this treatment in 2003, a total of ~0.0064 Ci (~0.38 g) of technetium-99 has been recovered.

### 2.9.3.3 216-S-10 Pond and Ditch

***C. J. Martin***




The 216-S-10 Pond and Ditch was active from 1951 through 1991 and received effluent primarily from the REDOX Plant chemical sewer. The site is monitored semiannually under RCRA interim status regulations (40 CFR 265.93(d) as referenced by WAC 173-303-400) for specified indicator parameters. The intent of this monitoring is to detect any impact from hazardous waste/hazardous waste constituents to the groundwater from past facility operations. Additional groundwater monitoring under the AEA tracks radionuclides beneath the WMA and the surrounding area. Appendix B includes a well location map and lists of wells and constituents monitored for the 216-S-10 Pond and Ditch.

RCRA groundwater monitoring has been conducted under interim status requirements since 1991. The 216-S-10 Pond and Ditch unit has not received liquid waste since October 1991. Because the 216-S-10 Pond and Ditch potentially received hazardous waste/hazardous waste constituents during its operational lifetime, Ecology has designated the site a treatment, storage, and/or disposal unit. This unit will be closed under RCRA and RCW 70.105 requirements. The RCRA closure plan for the 216-S-10 Pond and Ditch is being coordinated with the CERCLA 200-CS-1 Operable Unit in accordance with the Tri-Party Agreement.

***Three new wells were installed at the 216-S-10 Pond and Ditch in FY 2008.***

The RCRA monitoring network utilized during FY 2008 consisted of two downgradient wells (well 299-W26-13 located near the pond and well 299-W26-14 located just east of the central portion of the ditch). All other shallow monitoring wells in the area have gone dry with the regional decline in water level. Upgradient well 299-W26-7 went dry in 2003. The network also included downgradient well 299-W27-2, which is screened at the bottom of the uppermost unconfined aquifer. RCRA requirements for interim status monitoring specify a minimum of one upgradient and three downgradient monitoring wells to monitor the site. All new RCRA wells installed at the Hanford Site are negotiated annually by Ecology, the DOE, and the EPA, and approved under the Tri-Party Agreement Milestone M-24-00. One new upgradient well (699-33-76) and two downgradient wells (699-32-76 and 699-33-75) were installed in FY 2008 as planned. These three wells will be added to the network and will undergo initial quarterly sampling beginning in FY 2009. During FY 2008, all wells were sampled as scheduled.

***Groundwater Flow.*** Groundwater flow conditions beneath the 216-S-10 Pond and Ditch have varied greatly over the past several decades because of changing wastewater disposal at and in areas surrounding the site. Groundwater flow has generally followed the regional direction to the east-southeast for the last several

years. During FY 2008, the direction and velocity of groundwater flow were consistent with FY 2007. The rate at which the water table is dropping has remained constant, at ~0.3 m/yr in all of the monitoring wells during FY 2008. Using an average hydraulic gradient of 0.0045, a hydraulic conductivity range of 10 to 150 m/day, and an effective porosity range of 0.1 to 0.2, the range of average linear velocities is 0.23 to 6.8 m/day (Appendix B).

***Groundwater Sampling.*** Under RCRA indicator parameter monitoring, required indicator parameters (pH, specific conductance, total organic carbon, and total organic halides) are compared between upgradient and downgradient wells using the most recent data. However, since the new upgradient well was completed during the FY 2008 monitoring period, the most recent data from the former upgradient well (299-W26-7 before it went dry in 2003) was used to provide background values of contaminant indicator parameters. At the completion of the FY 2009 monitoring cycle, data from the new upgradient well (699-33-76) will be used to calculate new background concentrations for use in the required upgradient/downgradient comparisons. Based on statistical evaluations of contamination indicator parameters conducted during FY 2008, there were no statistically significant differences (i.e., constituents in the downgradient wells were not elevated compared to the upgradient well). Therefore, this site remains in detection monitoring.

***No exceedances of an indicator parameter were found during FY 2008, so the 216-S-10 Pond and Ditch remained in detection monitoring.***

Several constituents detected in wells near the 216-S-10 Pond and Ditch are being tracked by the monitoring network. Chromium is being tracked because it was elevated above the drinking water standard for several years in upgradient well 299-W26-7 before it went dry. Also, elevated concentrations of nickel (206 µg/L for both filtered and unfiltered samples) and carbon tetrachloride (5.6 µg/L) have been detected again during FY 2008 in the deep monitoring well 299-W27-2. Because there have been no detections of nickel in the shallow monitoring wells, the 216-S-10 Pond and Ditch is not believed to be the source of this constituent. Carbon tetrachloride concentrations in well 299-W27-2 have averaged above the drinking water standard (5 µg/L) since 2001. The source is believed to be liquid waste disposal sites at the Plutonium Finishing Plant (northwest of WMA U). Well 699-33-75 was recently completed adjacent to well 299-W27-2 but screened at a shallower depth. Carbon tetrachloride has been detected in this well at concentrations up to 45 µg/L. The new upgradient well (699-33-76) also has measurable concentrations of carbon tetrachloride supporting the assertion of an upgradient source.

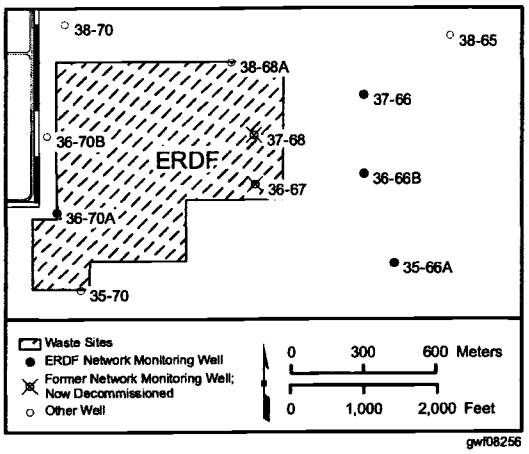
Elevated dissolved chromium concentrations at well 299-W26-7 had exceeded the drinking water standard (100 µg/L) before the well went dry. This may have been caused by short-term releases migrating through the vadose zone from past effluent releases to the pond or from upgradient sources. Historical records document a 1983 release to the 216-S-10 Ditch of a high-salt waste (simulated tank waste) containing hexavalent chromium. Although well 299-W26-7 was designated as an upgradient well, it is located very close to one lobe of the pond system and may have been affected by drainage spreading laterally in the vadose zone or by a mound on the water table when the facility was in operation. A REDOX Plant disposal pond (located immediately upgradient of the 216-S-10 Pond and Ditch) also is a potential source of chromium contamination. Chromium is a hazardous waste constituent for the treatment, storage, and disposal unit, and the 216-S-10 Pond and Ditch cannot currently be ruled out as the source of the contamination.

Nitrate concentrations were covariate with chromium concentrations in wells 299-W26-7, 299-W26-9, 299-W26-10, and 299-W26-12, which are now dry. The

upgradient well 299-W26-7 had the highest nitrate concentrations. These and other data presented in PNNL-14070, *Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*, suggest that the 216-S-10 Pond could be the source of this nitrate and chromium increase. Although chromium and nitrate were elevated in upgradient well 299-W26-7 prior to when it went dry, substantial concentrations of these constituents have not been detected in the downgradient wells. Well 299-W26-13 (located downgradient of the pond and which replaced well 299-W26-9) shows increasing levels of dissolved chromium (from 21 µg/L in January 2007 to 28 µg/L in January 2008) and nitrate (from 10 to 12 mg/L), neither of which exceed drinking water standards. By comparison chromium in the other downgradient well (299-W26-14, located away from the pond and centered along the ditch portion of the facility) remains essentially undetected. This difference may indicate a localized source near the pond.

### 2.9.3.4 Environmental Restoration Disposal Facility

***R. L. Weiss***




The ERDF is a low-level radioactive mixed waste facility where waste from surface remedial actions on the Hanford Site is disposed. Groundwater monitoring is regulated under a CERCLA record of decision (EPA/ROD/R10-95/114). The record of decision states that groundwater monitoring will be conducted according to RCRA regulations. The site was designed to meet RCRA standards, although it is not actually permitted as a RCRA facility.

The groundwater flow direction beneath the site is toward the east-northeast. One upgradient well (699-36-70A) and three downgradient wells (699-37-66, 699-36-66B, and 699-35-66A) are sampled semiannually, typically in March and September. All monitoring wells were sampled as planned during FY 2008. During FY 2008, former downgradient wells 699-36-67 and 699-37-68 were decommissioned to allow for the next ERDF expansion to the east. Two new downgradient wells (699-37-66 and 699-36-66B) were constructed prior to the March sampling as replacements. Appendix B includes a well location map and lists of wells and constituents monitored for the ERDF. Section 3.1 provides a discussion of leachate monitoring at this facility. WCH-295, *Groundwater and Leachate Monitoring and Sampling at the ERDF, CY 2007,* provides detailed information for calendar year 2007 groundwater and leachate monitoring results. Calendar year 2008 results will be described in an upcoming report. During FY 2008, a revised groundwater-monitoring plan was issued (WCH-198, *Groundwater Protection Plan for the Environmental Restoration Disposal Facility*).

***Results of groundwater monitoring at the Environmental Restoration Disposal Facility continued to indicate that the facility has not adversely affected groundwater quality.***

***Groundwater Sampling.*** The results of groundwater monitoring at the ERDF continued to indicate that the facility has not adversely affected groundwater quality. Several constituents (tritium, iodine-129, nitrate, and carbon tetrachloride) are present in the groundwater near or above drinking water standards, but these constituents are elevated in both the upgradient and downgradient wells. Figures 2.8-3, 2.9-7, 2.9-9, and 2.9-10 indicate that these plumes originated in the 200 West Area and have migrated toward the ERDF.

Both filtered and unfiltered samples are collected for metals (except for uranium samples, which are unfiltered). While no sampling results were noted substantially out of trend during FY 2008, trending evaluation between the decommissioned wells (699-36-67 and 699-37-68) and the replacement wells (699-37-66 and 699-36-66B)

was not attempted. To better establish new trending information for the replacement wells, these wells were sampled in June 2008 and will be sampled in December 2008. Except as noted below, contaminant concentrations in the replacement wells were similar to the results from the recently decommissioned wells or bounded by the sampling results from wells 699-36-70A and 699-35-66A.

The uranium concentrations in wells 699-36-70A and 699-35-66A are consistent with Hanford Site background levels. Both technetium-99 and gross beta are trending downward in the upgradient well 699-36-70A. The technetium-99 concentration is an order of magnitude below the drinking water standard (900 pCi/L), and gross beta is approximately half the drinking water standard (50 pCi/L). There are indications that technetium-99 and gross beta activities may have peaked in downgradient well 699-35-66A in FY 2007. Nitrate levels are decreasing in upgradient well 699-36-70A, and remain stable for well 699-35-66A at a very low level. These trends will continue to be monitored.

Barium results for new downgradient well 699-37-66 averaged 78 µg/L during FY 2008. This value is greater than in the other monitoring wells, but below maximum concentrations encountered in other wells early in the monitoring program. Nitrate concentrations in this well averaged 177 mg/L during the fiscal year. This is more than twice the concentrations observed in the other monitoring wells and are the highest concentrations encountered in the monitoring program. However, these values are below the 226 mg/L tolerance limit established in the monitoring plan (WCH-198).

One analytical issue was encountered during the FY 2008 sampling. Nitrate measurements via ion chromatographic analyses and nitrogen as nitrate/nitrite via colorimetric analyses were not self-consistent in several of the March and September sampling events. Concentrations reported by the ion chromatographic method are consistent relative to previous samples, while some colorimetric analysis appear low relative to the ion chromatographic values. This is still under investigation at the laboratory. This issue has no substantial effect on the data analysis because of the redundancy in the nitrate results.

***Groundwater monitoring in the 200-UP-1 groundwater interest area includes the following monitoring activities.***

***CERCLA and AEA Monitoring***

- ***Fifty-nine wells are scheduled for quarterly to biennial sampling. In FY 2008, three wells were not sampled and one well was delayed until early FY 2009.***
- ***Four wells were scheduled for semiannual sampling at the Environmental Restoration Disposal Facility. Two new wells replaced two wells that were decommissioned.***

***Facility Monitoring (Appendix B)***

- ***Eight wells are scheduled for quarterly sampling at Waste Management Area U for RCRA and AEA.***
- ***Twenty wells are scheduled for quarterly sampling at Waste Management Area S-SX for RCRA and AEA. Two quarterly samples were missed during the fiscal year.***
- ***Three wells are scheduled for semiannual sampling under RCRA for the 216-S-10 Pond and Ditch. Three new wells were installed and will be sampled beginning in FY 2009.***

**Table 2.9-1. Summary of Contaminant Mass Removed from the Effluent During Treatment for Pump-and-Treat Operations at 200-UP-1 Operable Unit.**

| Contaminant | Total for FY08 [a] | Totals Since Startup, March 1994 |
|---|---|---|
| Uranium (kg) | 3.5 | 216 |
| Technetium-99 (g [Ci]) [b] | 4.6 (0.08) | 124 (2.1) |
| Carbon tetrachloride (kg) | 3.0 | 37.7 |
| Nitrate (kg) | 6,380 | 41,500 |

The totals are from fiscal year 2008 and totals since startup of operations.
[a] Mass removed is based on total volume extracted.
[b] For technetium-99, grams convert to curies at a ratio of 58.7 g/Ci.

**Table 2.9-2. Quantity of Treated Groundwater and Technetium-99 Mass Removed from the Aquifer during Extended Purging at Well 299-W23-19.**

| Sample Date | Volume of Water Treated L (gal) | Technetium-99 Concentration (pCi/L) | Activity of Technetium-99 Removed (Ci) | Mass of Technetium-99 Removed (g) |
|---|---|---|---|---|
| 29-Jan-08 | 4,346 (1,148) | 57,000 | $2.5 \times 10^{-4}$ | 0.015 |
| 17-Mar-08 | 5,451 (1,440) | 52,000 | $2.8 \times 10^{-4}$ | 0.017 |
| 9-Jun-08 | 5,527 (1,460) | 65,500 | $3.6 \times 10^{-4}$ | 0.021 |
| 16-Sep-08 | 4,860 (1,284) | 46,000 | $2.2 \times 10^{-4}$ | 0.013 |
| **FY 08 Totals** | **20,184 (5,332)** | **NA** | **$1.1 \times 10^{-3}$** | **0.066** |
| **Totals Since Startup*** | **103,883 (27,444)** | **NA** | **$6.4 \times 10^{-3}$** | **0.379** |

The totals are from fiscal year 2008 and totals since startup of extended purging.
* Totals for all quarterly events since startup of extended purging in March 2003.

**Figure 2.9-1. Facilities and Groundwater Monitoring Wells in the 200-UP-1 Groundwater Interest Area.**

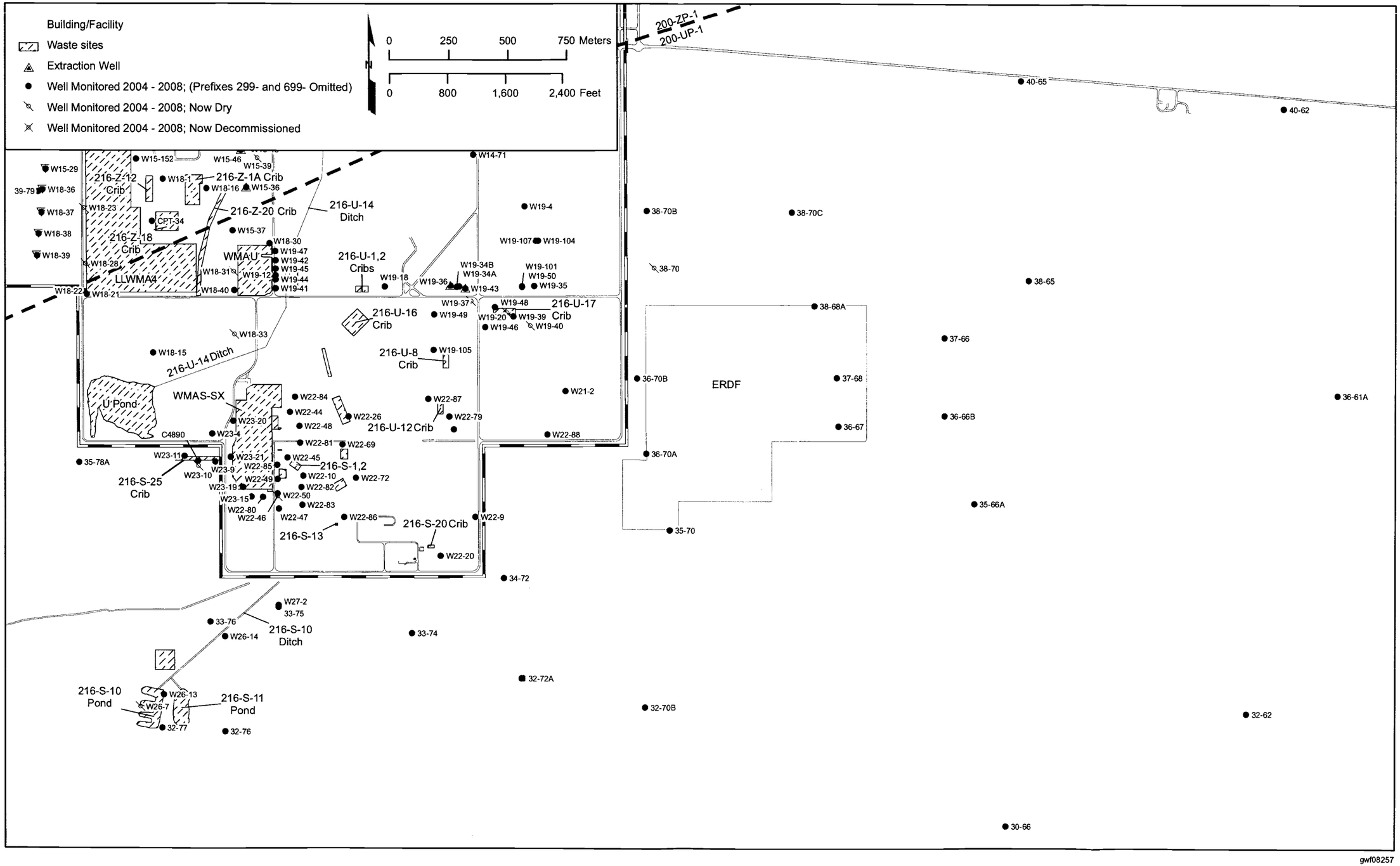


**Figure 2.9-2. Water-Table Map for 200-UP-1 Groundwater Interest Area.**

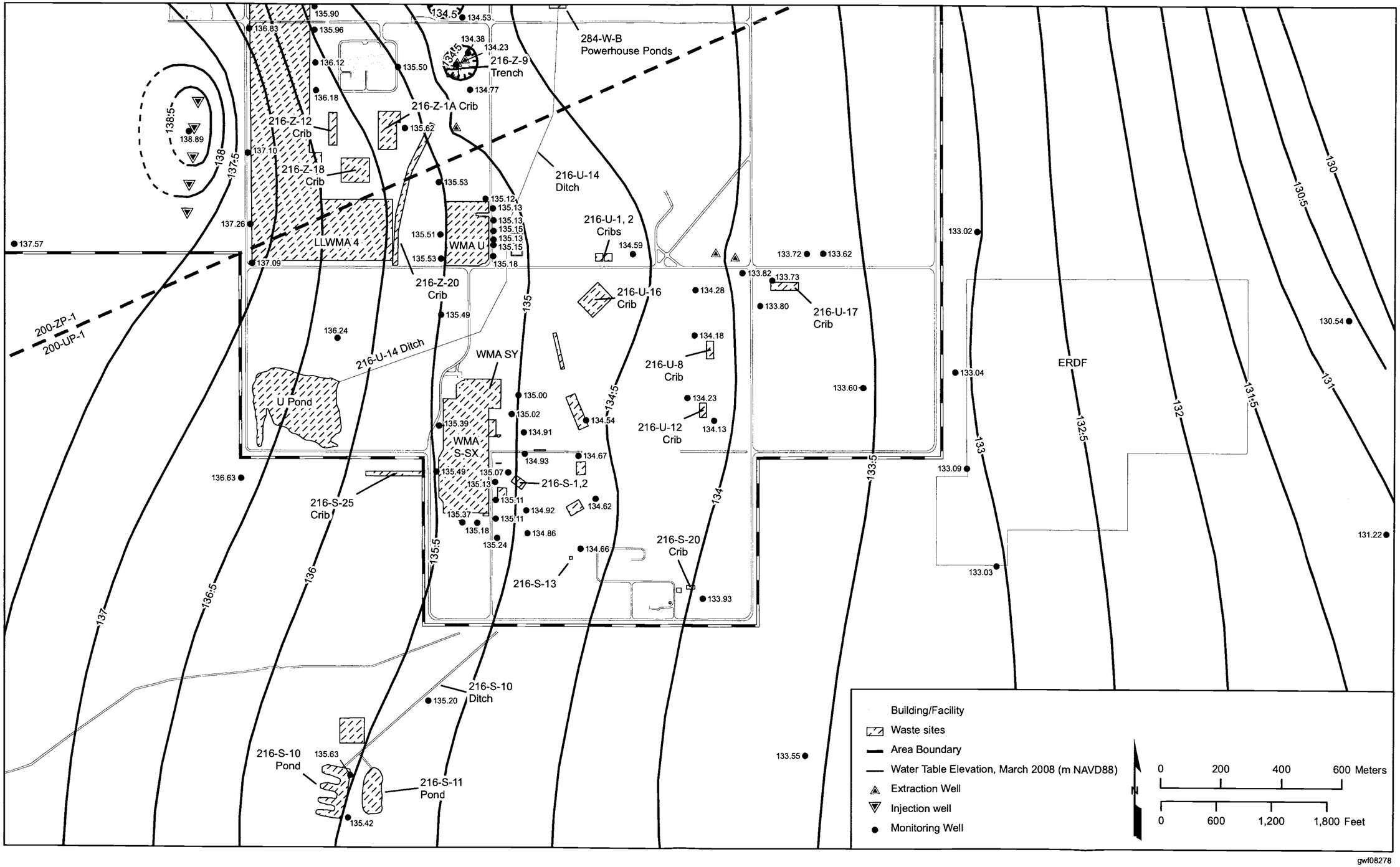


**Figure 2.9-3. Average Technetium-99 Concentrations in the 200-UP-1 Groundwater Interest Area, Upper Part of Unconfined Aquifer.**

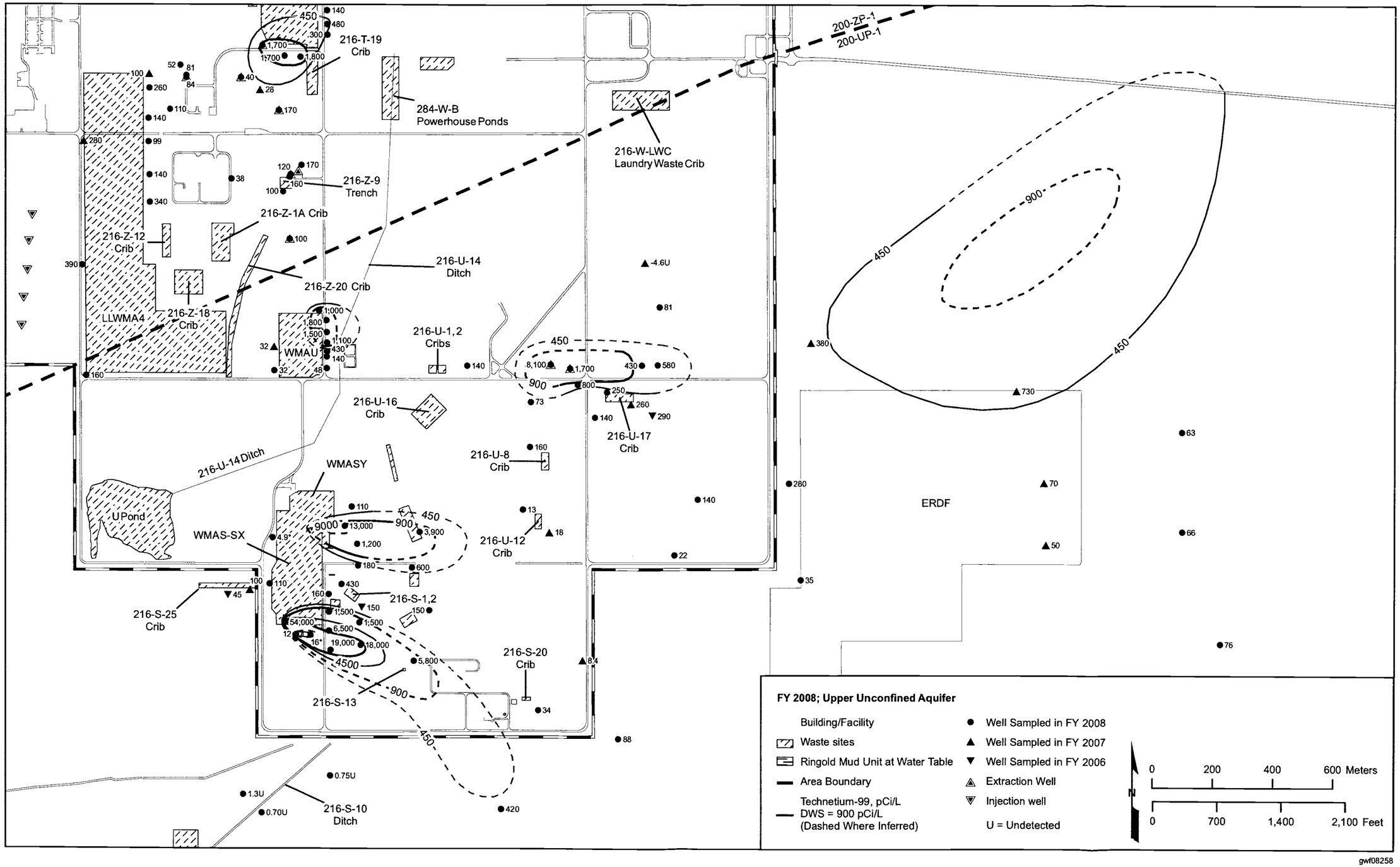


**Figure 2.9-4. Chromium and Technetium-99 Concentrations in Well 299-W23-19, Southern Portion of Waste Management Area S-SX.**

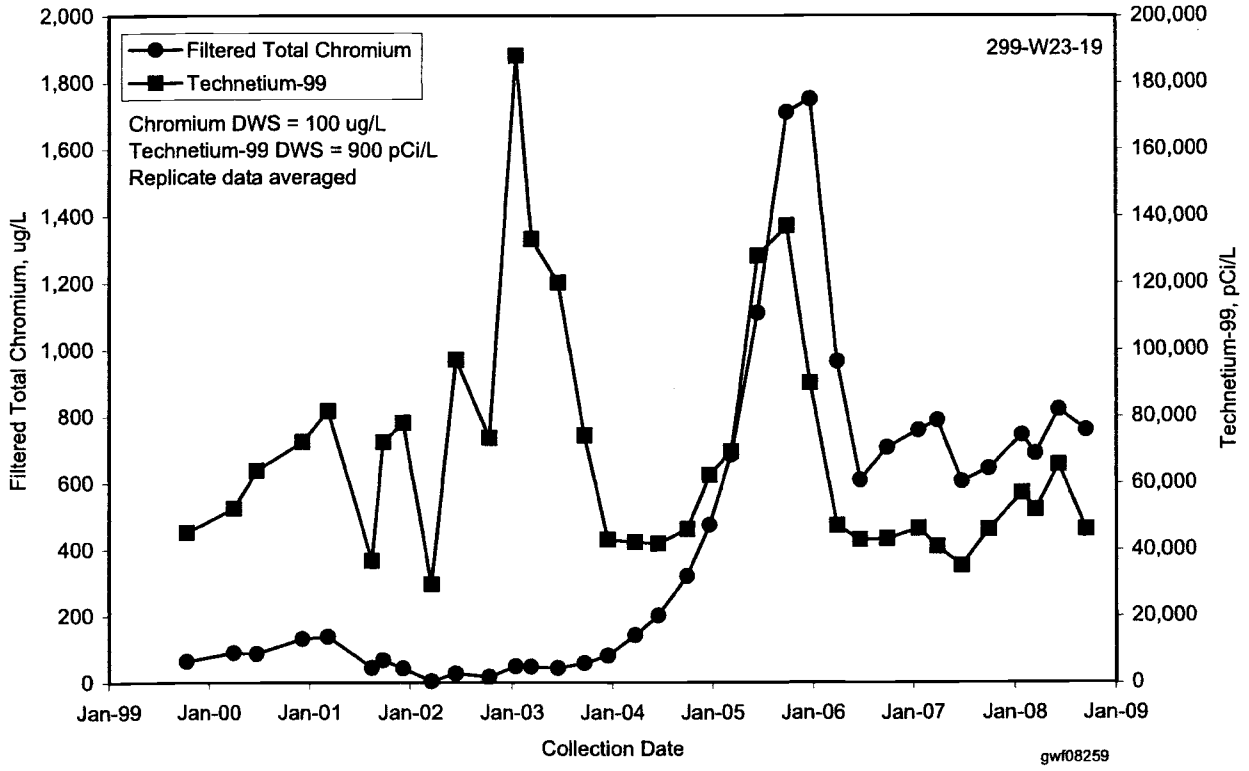


**Figure 2.9-5. Average Uranium Concentrations in the 200-UP-1 Groundwater Interest Area, Upper Part of Unconfined Aquifer.**

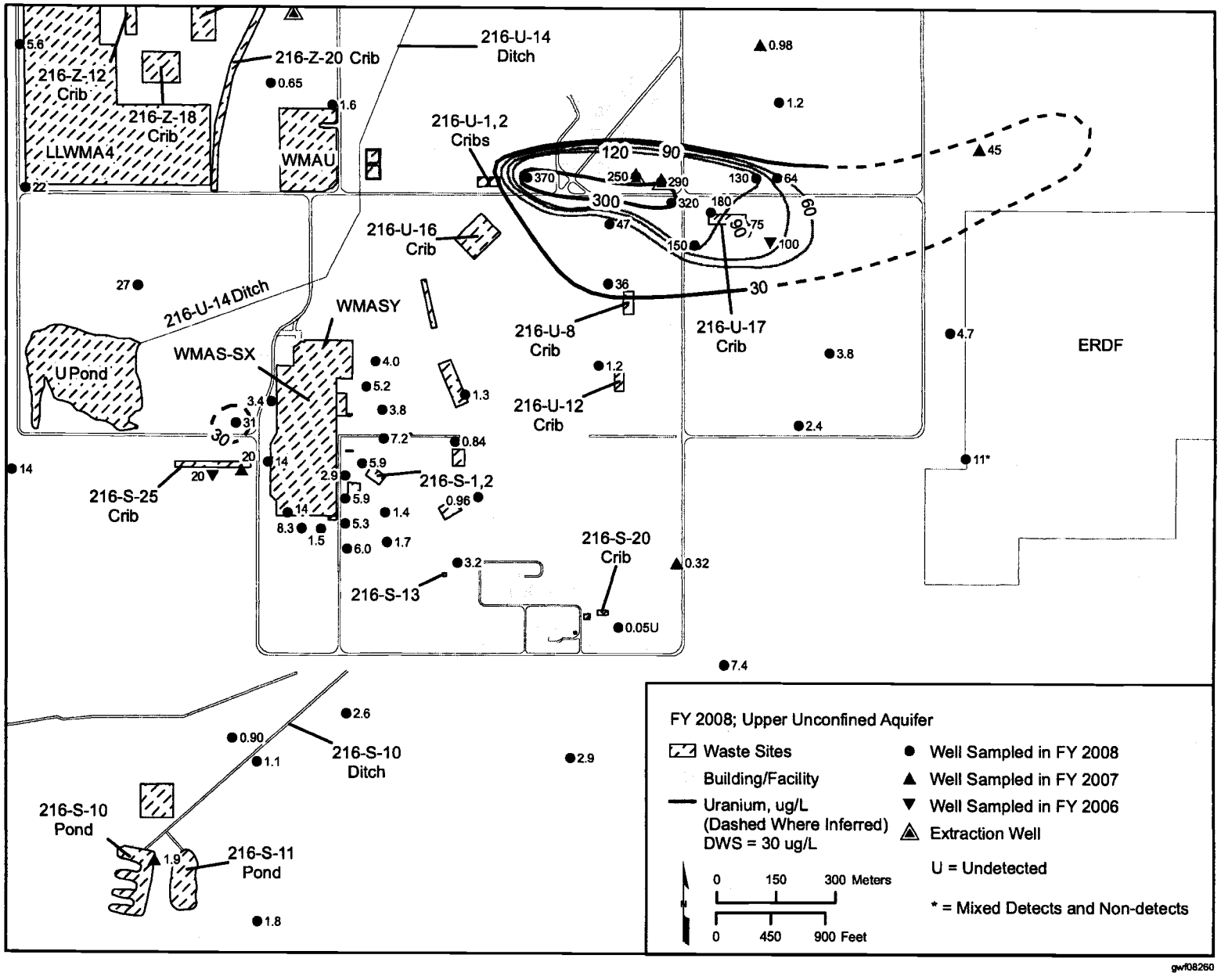


**Figure 2.9-6. Uranium Concentrations in Well 299-W19-18 near the 216-U-1/2 Cribs.**

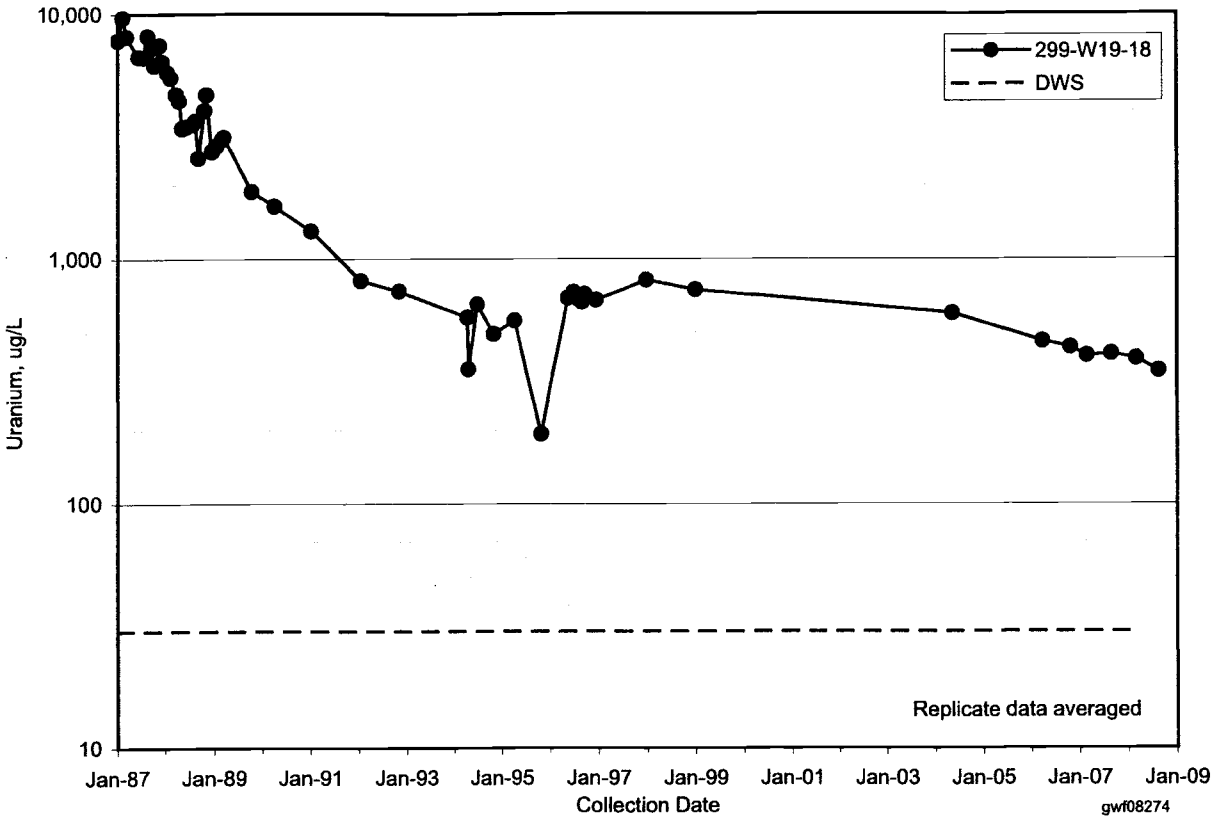


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**Figure 2.9-7. Average Tritium Concentrations in the 200-UP-1 Groundwater Interest Area.**

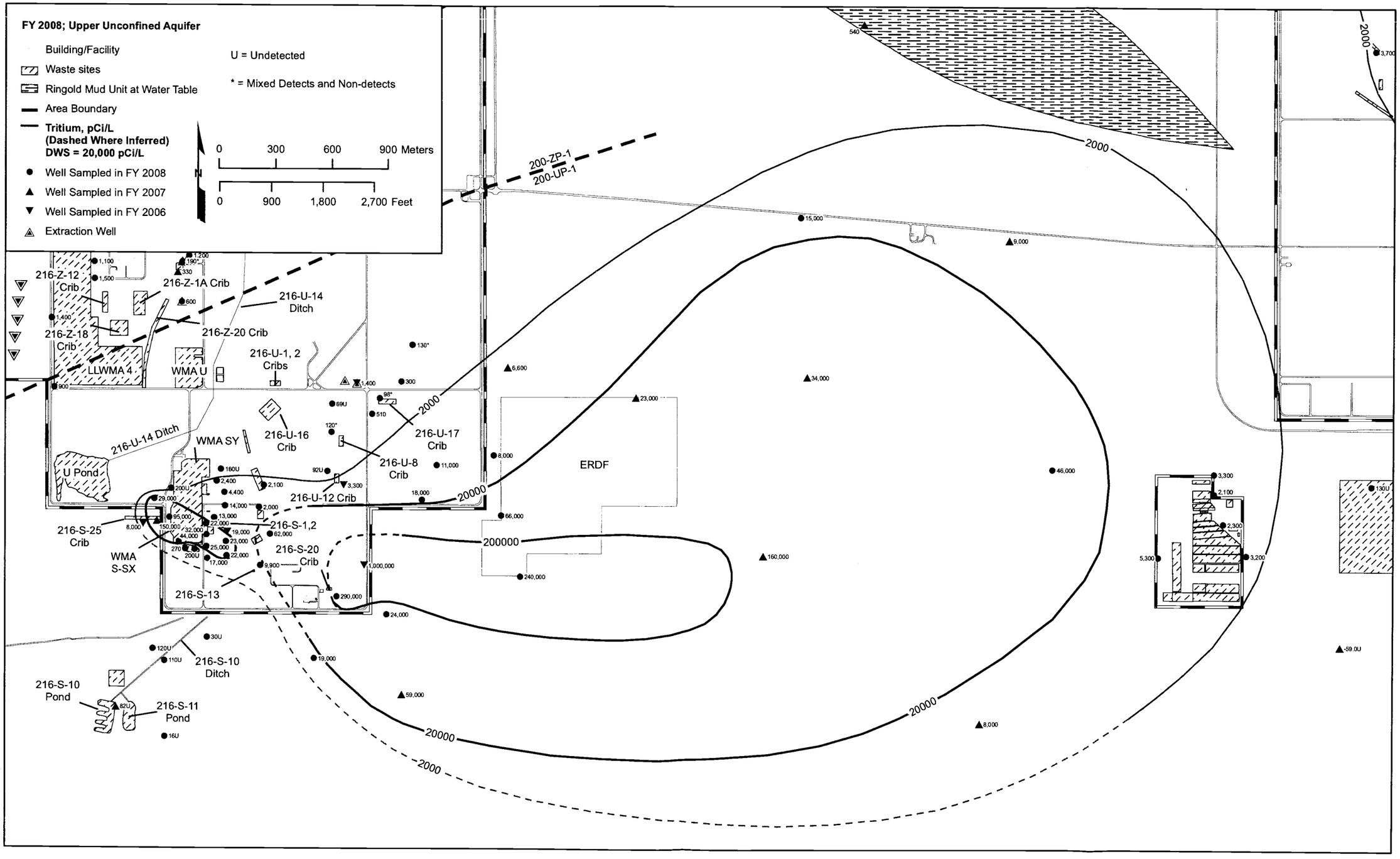


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**Figure 2.9-8. Tritium Concentrations in Well 299-W23-4 near the 216-S-21 Crib, Upper Part of Unconfined Aquifer.**

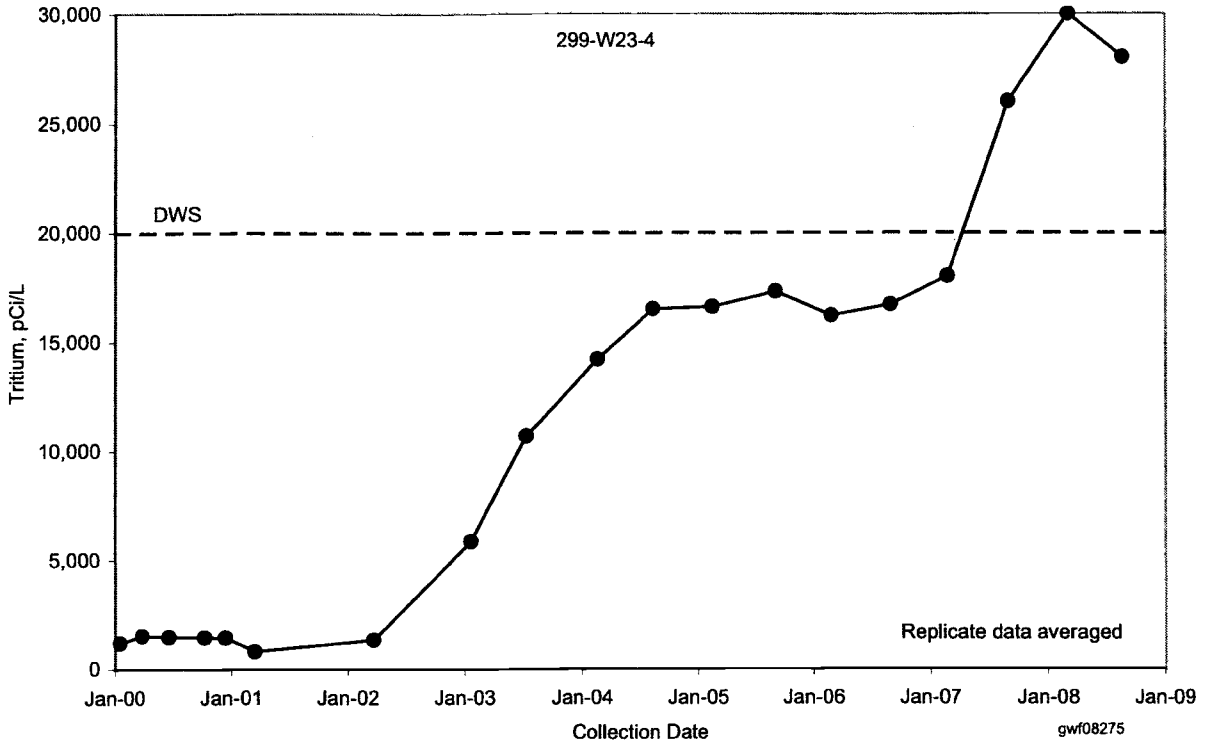

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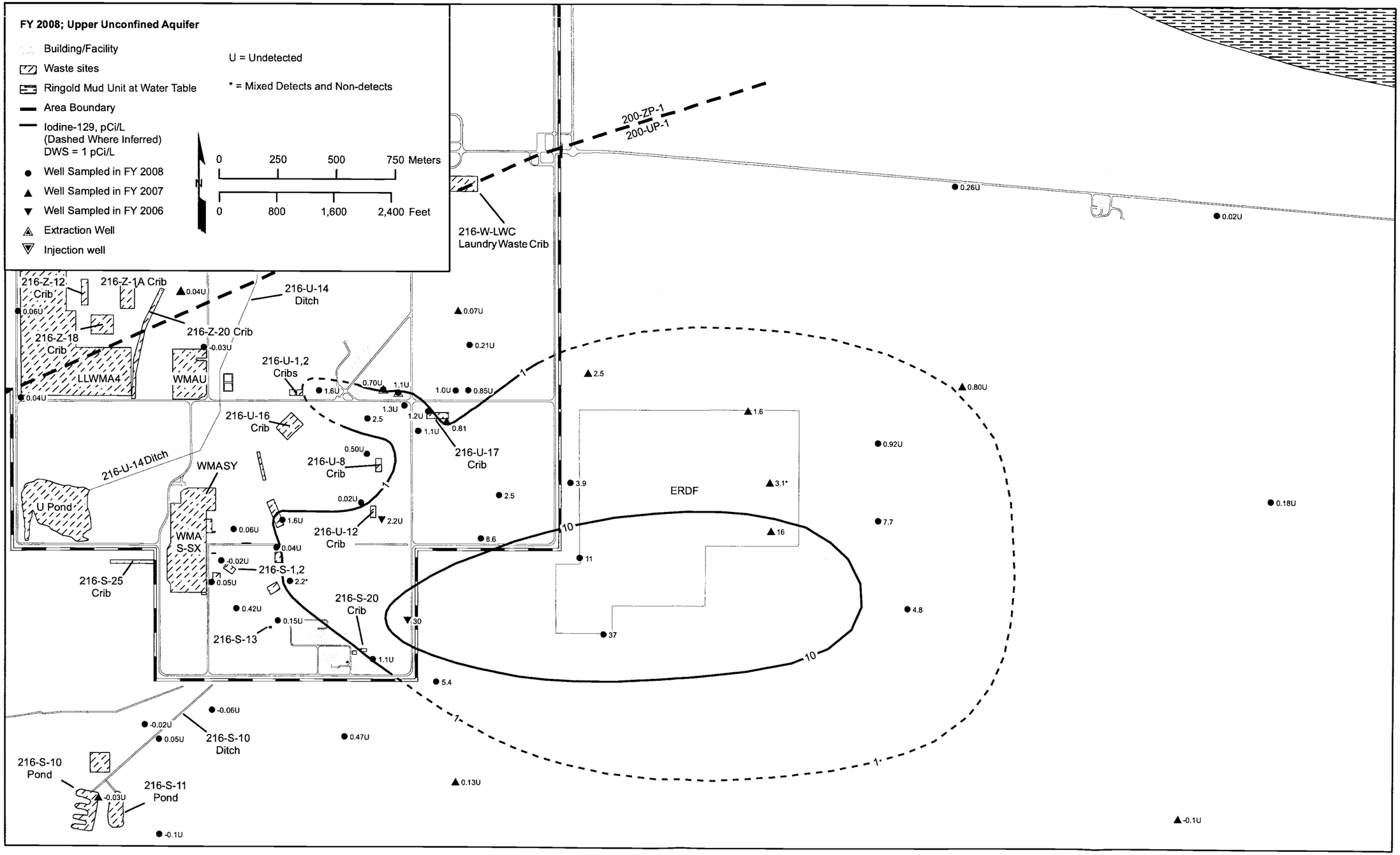
**Figure 2.9-9. Average Iodine-129 Concentrations in the 200-UP-1 Groundwater Interest Area, Upper Part of Unconfined Aquifer.**




gwf08262

**Figure 2.9-10. Average Nitrate Concentrations in the 200-UP-1 Groundwater Interest Area, Upper Part of Unconfined Aquifer.**

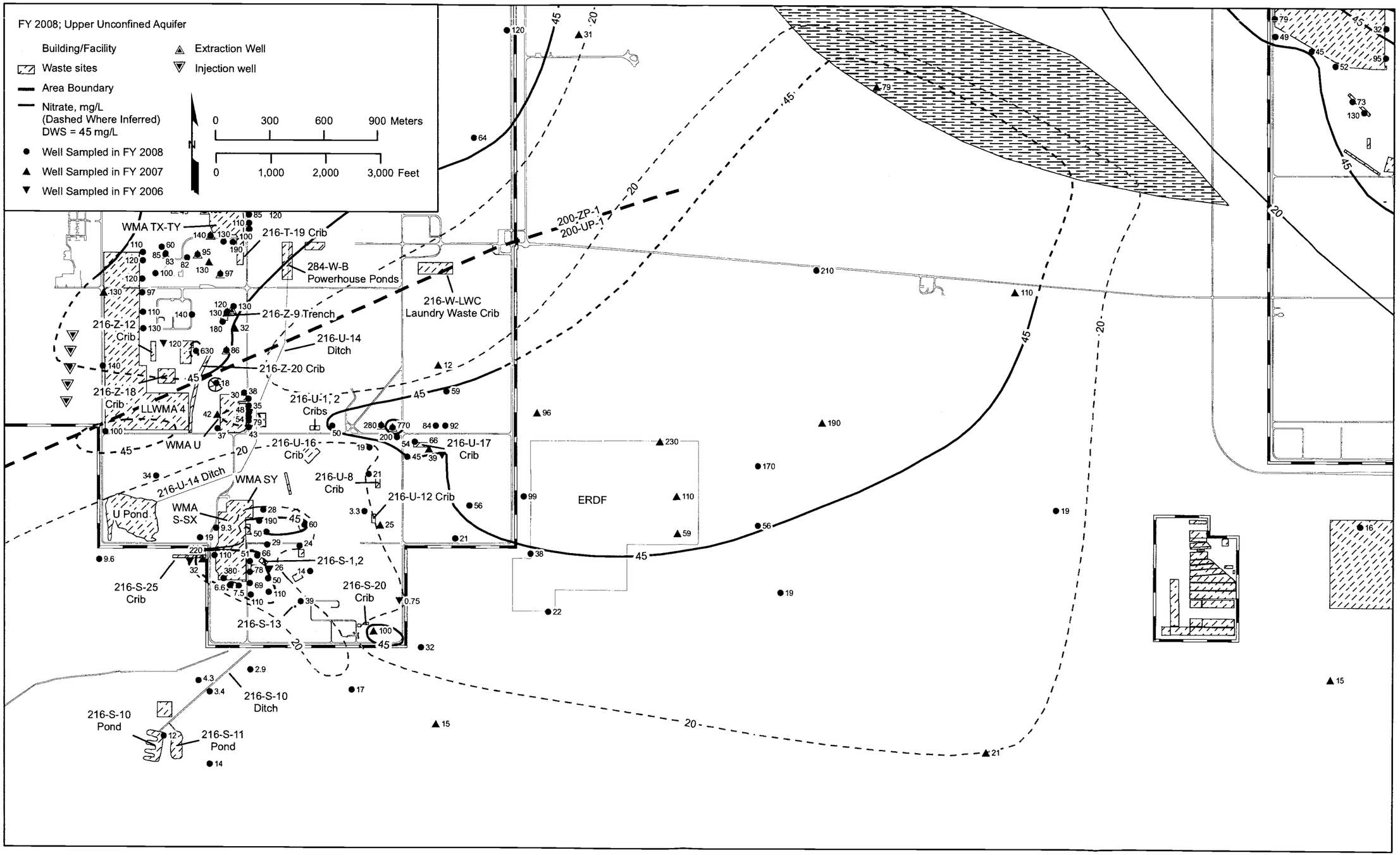


**Figure 2.9-11. Carbon Tetrachloride Concentrations for Depth-Discrete Sampling in Wells at the 200-UP-1 Groundwater Interest Area.**

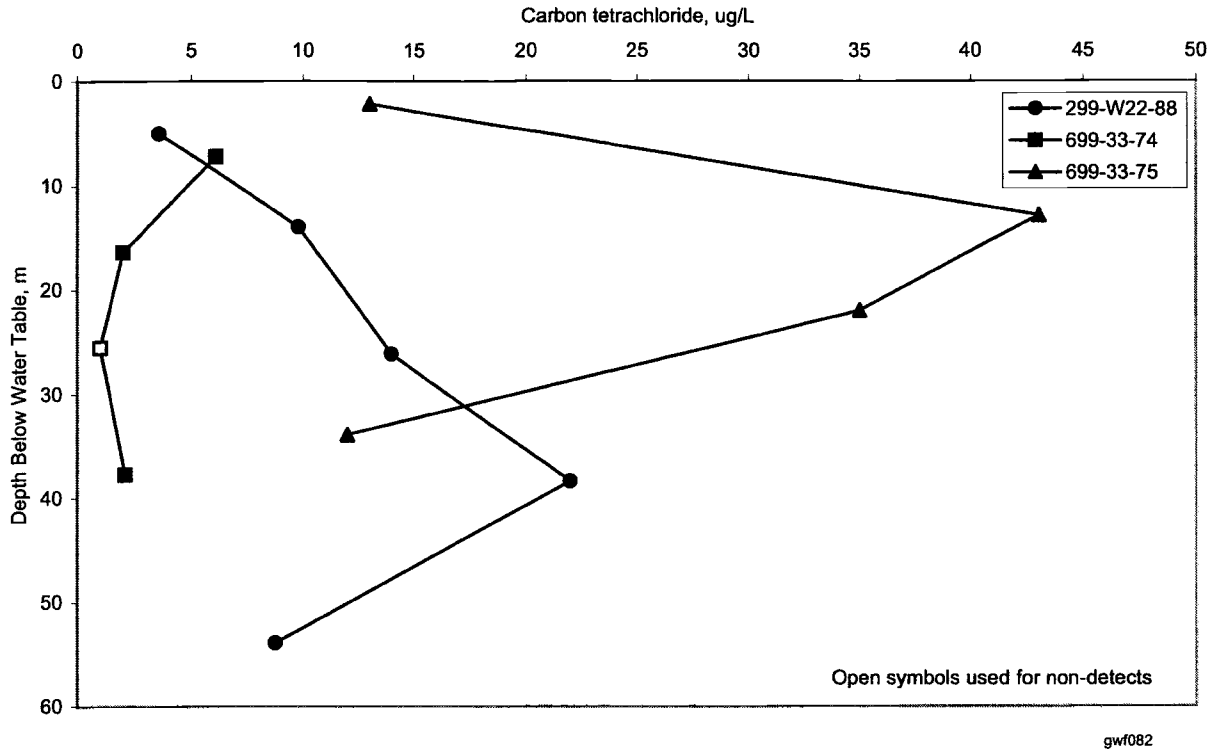


**Figure 2.9-12. Average Technetium-99 Concentrations in the 200-UP-1 Pump-and-Treat System Area, Upper Part of Unconfined Aquifer.**

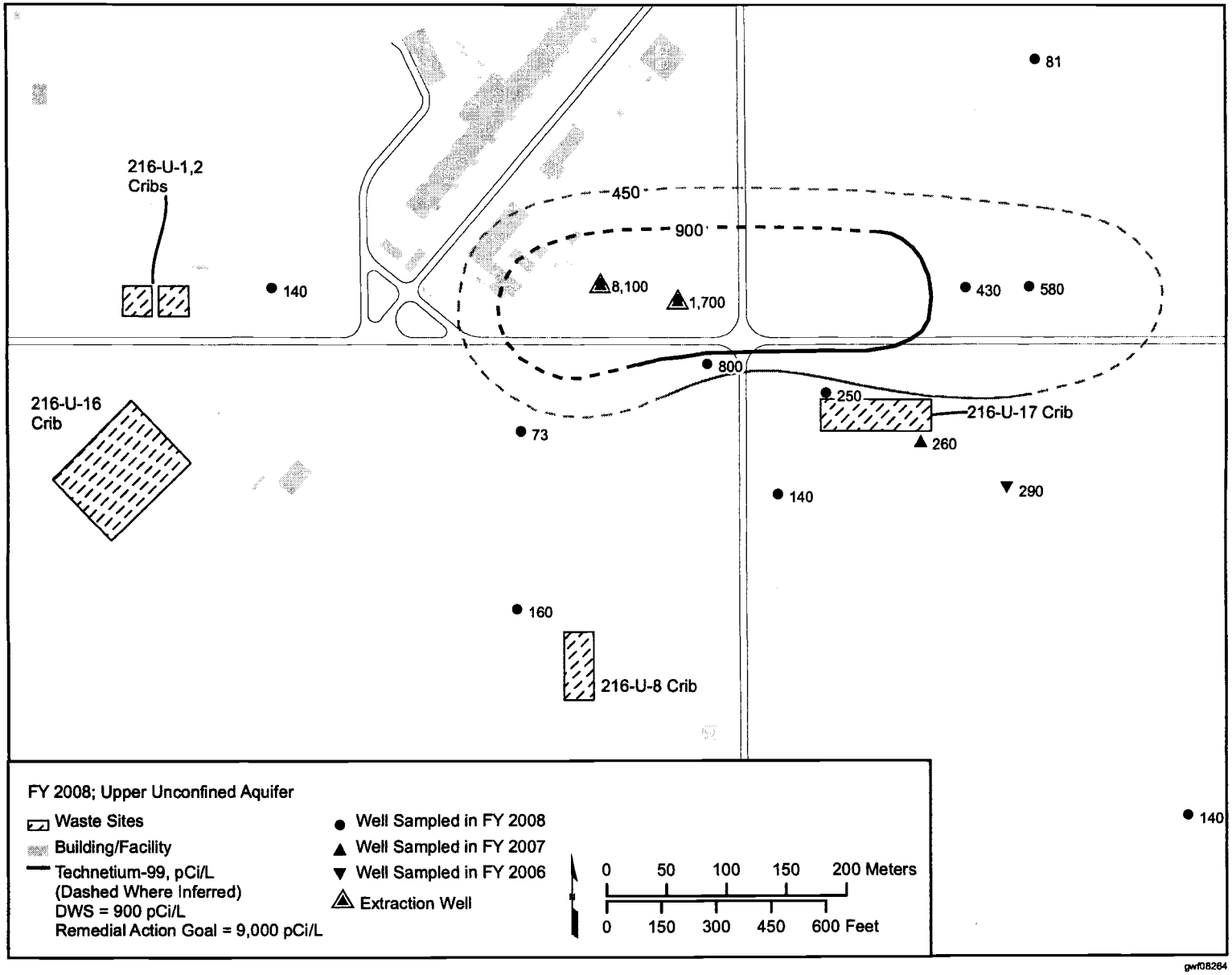


**Figure 2.9-13. Average Uranium Concentrations in the 200-UP-1 Pump-and-Treat System Area, Upper Part of Unconfined Aquifer.**

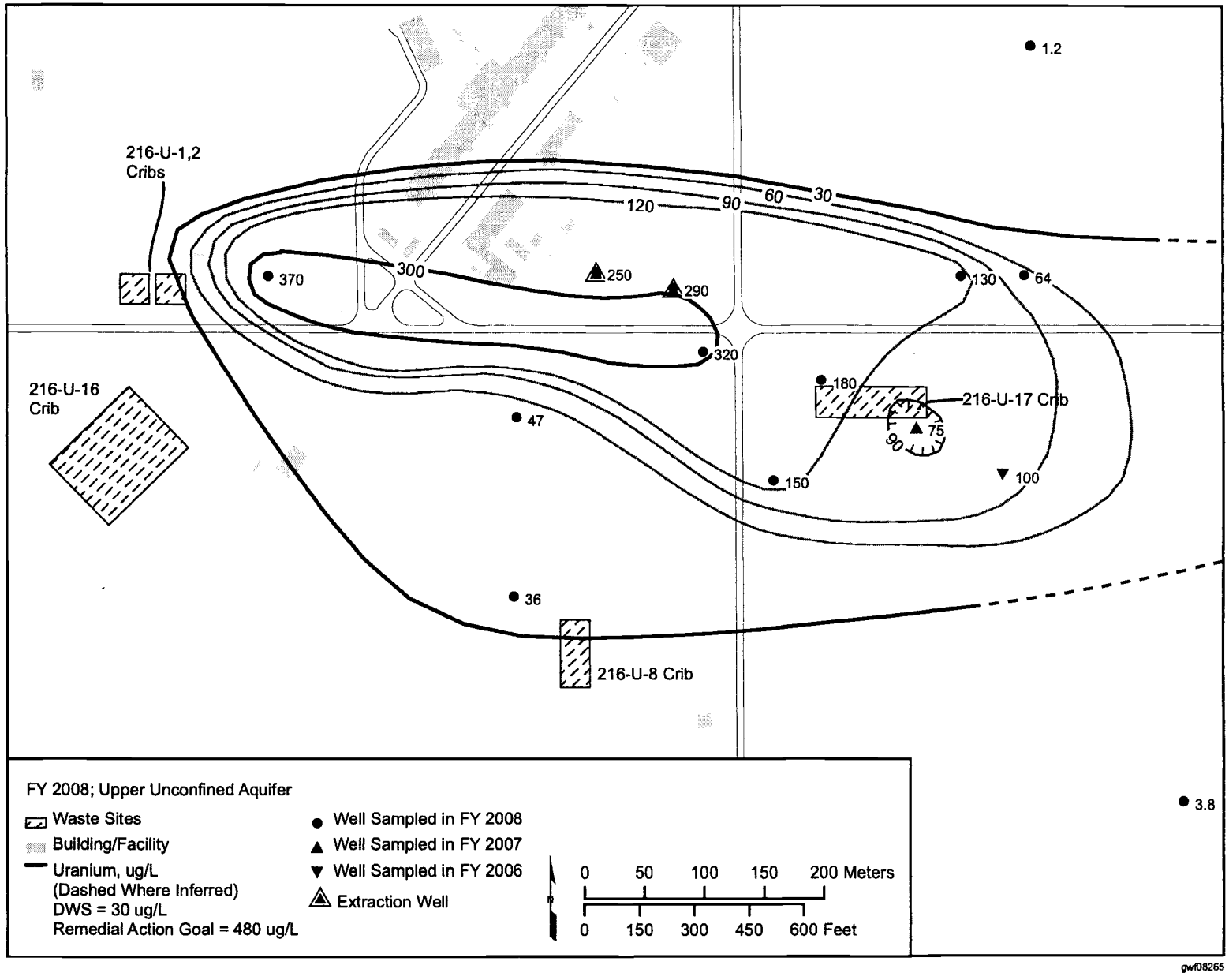


**Figure 2.9-14. Uranium Concentrations in Selected Wells in the 200-UP-1 Pump-and-Treat System Area.**

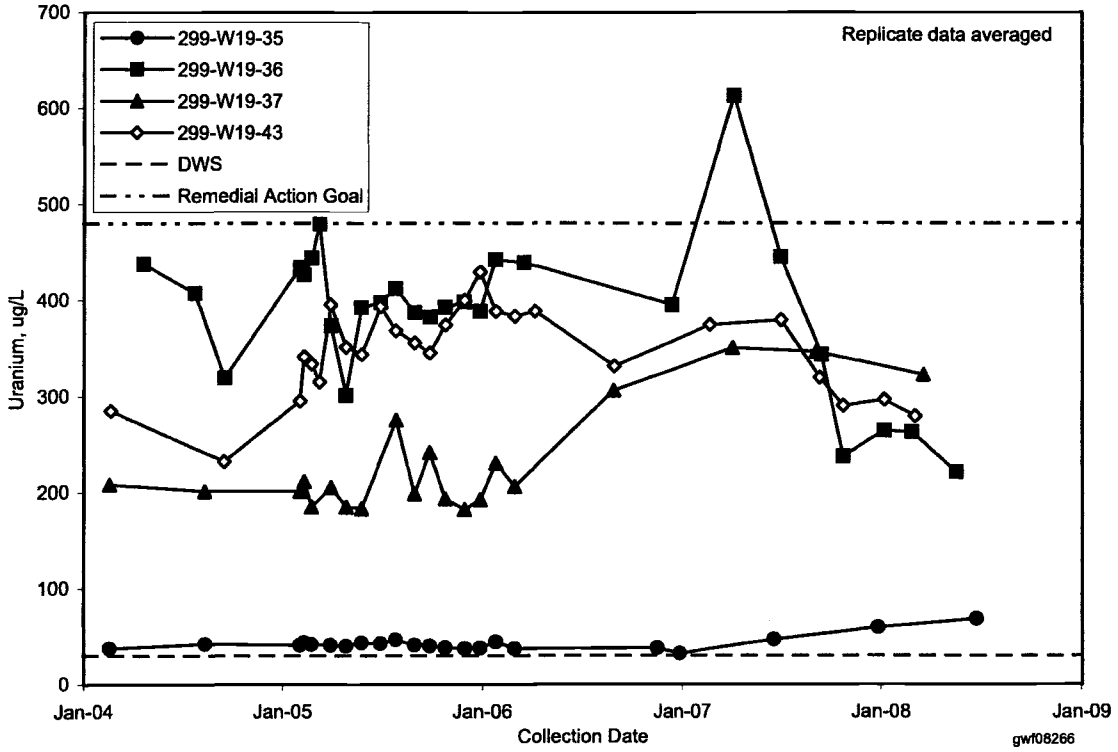



**Figure 2.9-15. Technetium-99 Concentrations in Selected Wells in the 200-UP-1 Pump-and-Treat System Area.**

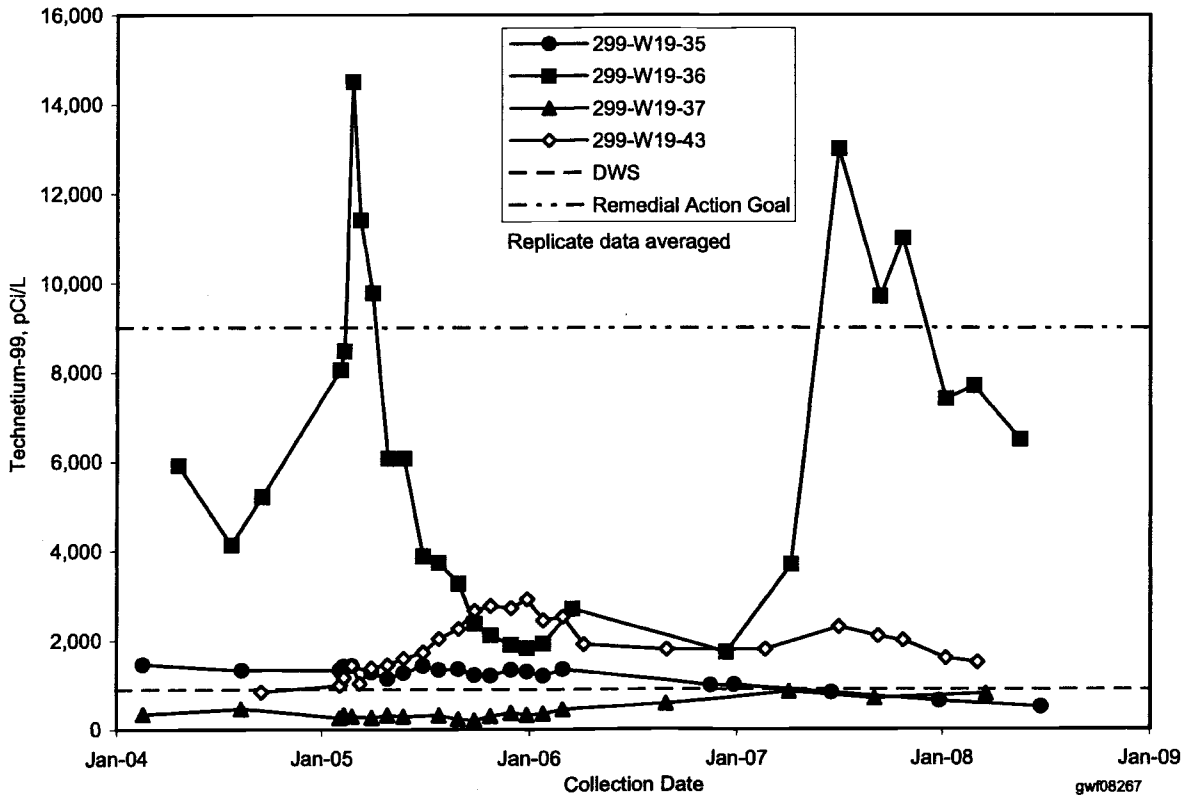


**Figure 2.9-16. Average Nitrate and Technetium-99 Concentrations in Waste Management Area U, Upper Part of Unconfined Aquifer.**

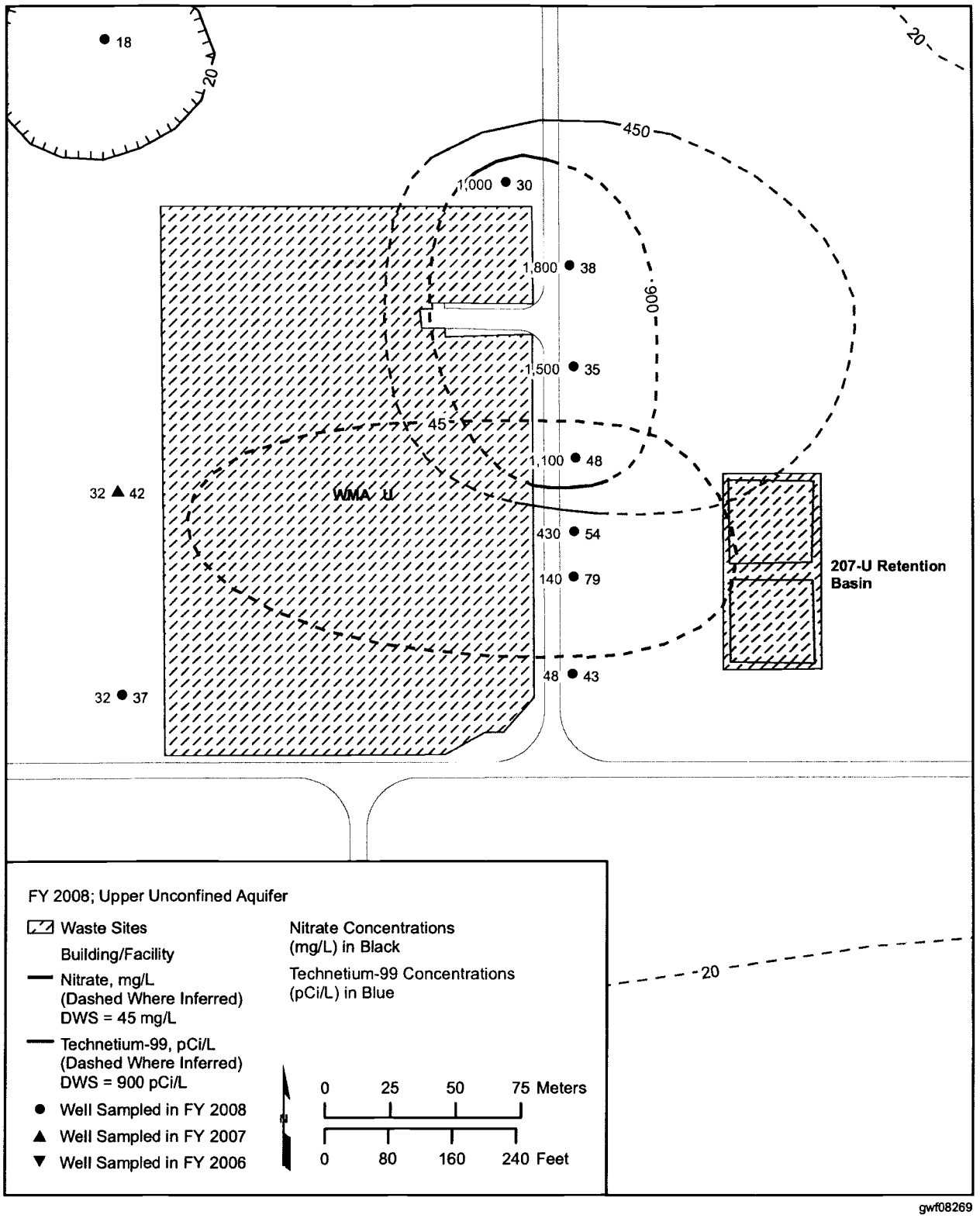


**Figure 2.9-17. Average Nitrate Concentrations in Waste Management Area S-SX, Upper Part of Unconfined Aquifer.**

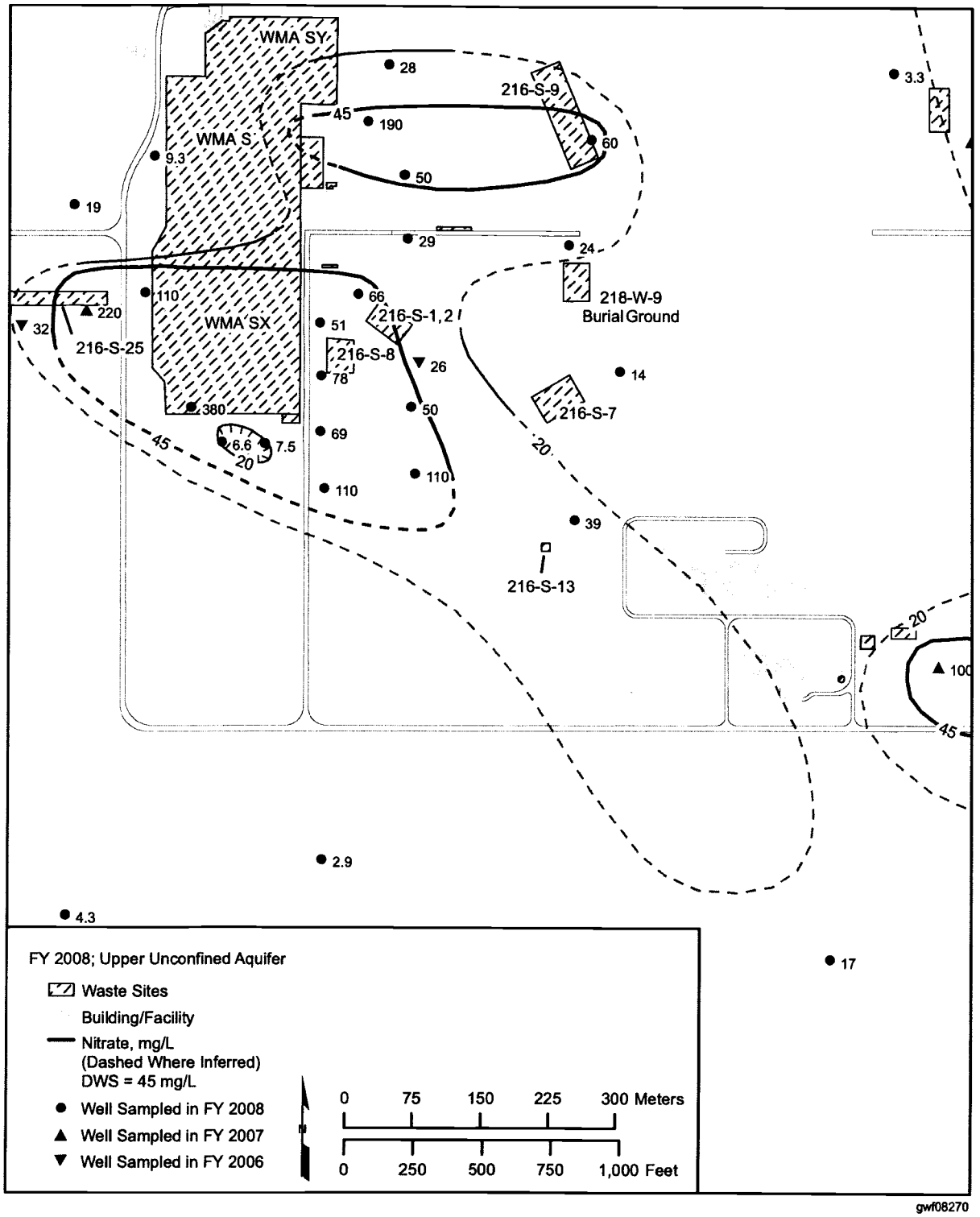


**Figure 2.9-18. Average Chromium Concentrations in Waste Management Area S-SX, Upper Part of Unconfined Aquifer.**

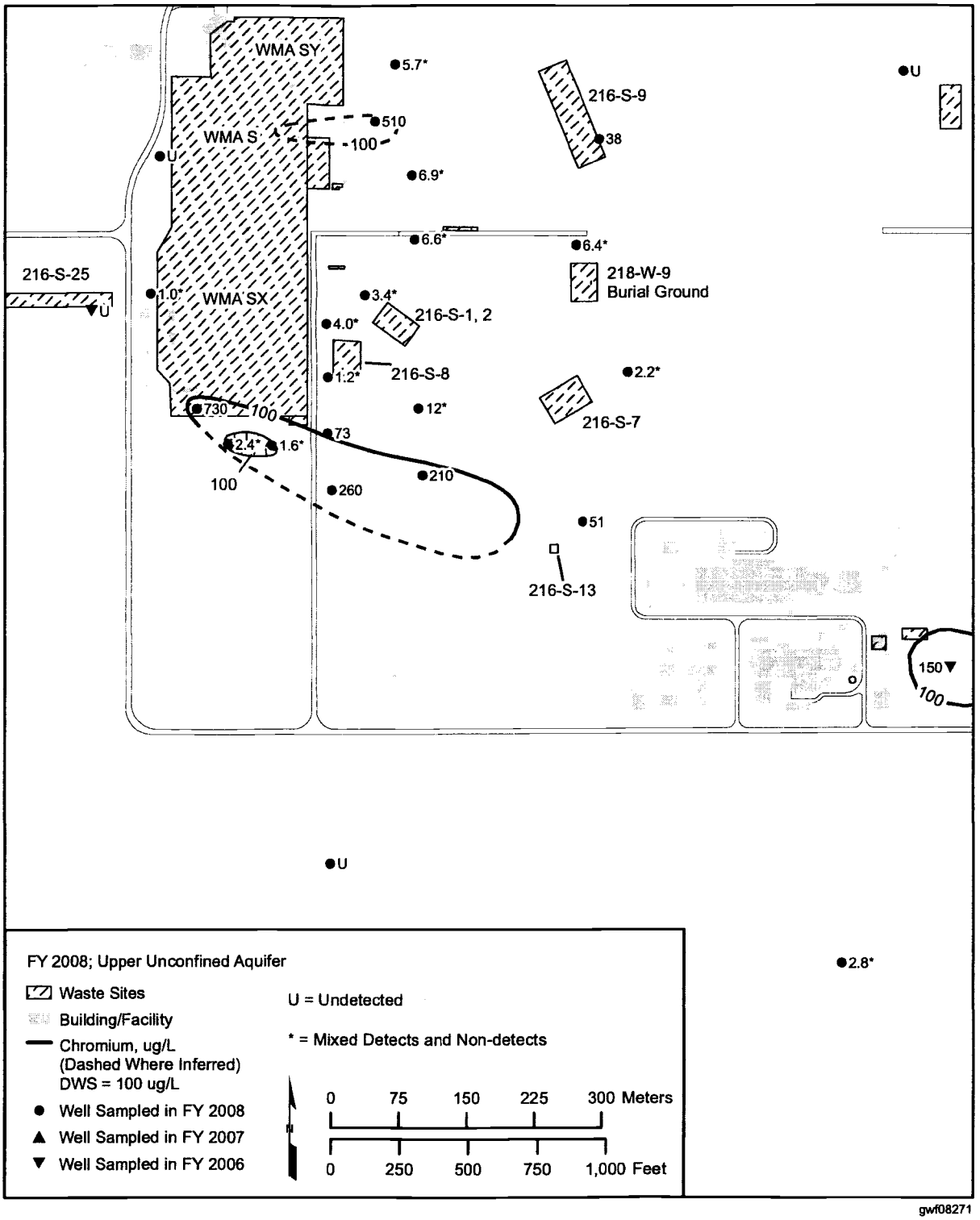


**Figure 2.9-19. Average Technetium-99 Concentrations in Waste Management Area S-SX, Upper Part of Unconfined Aquifer.**

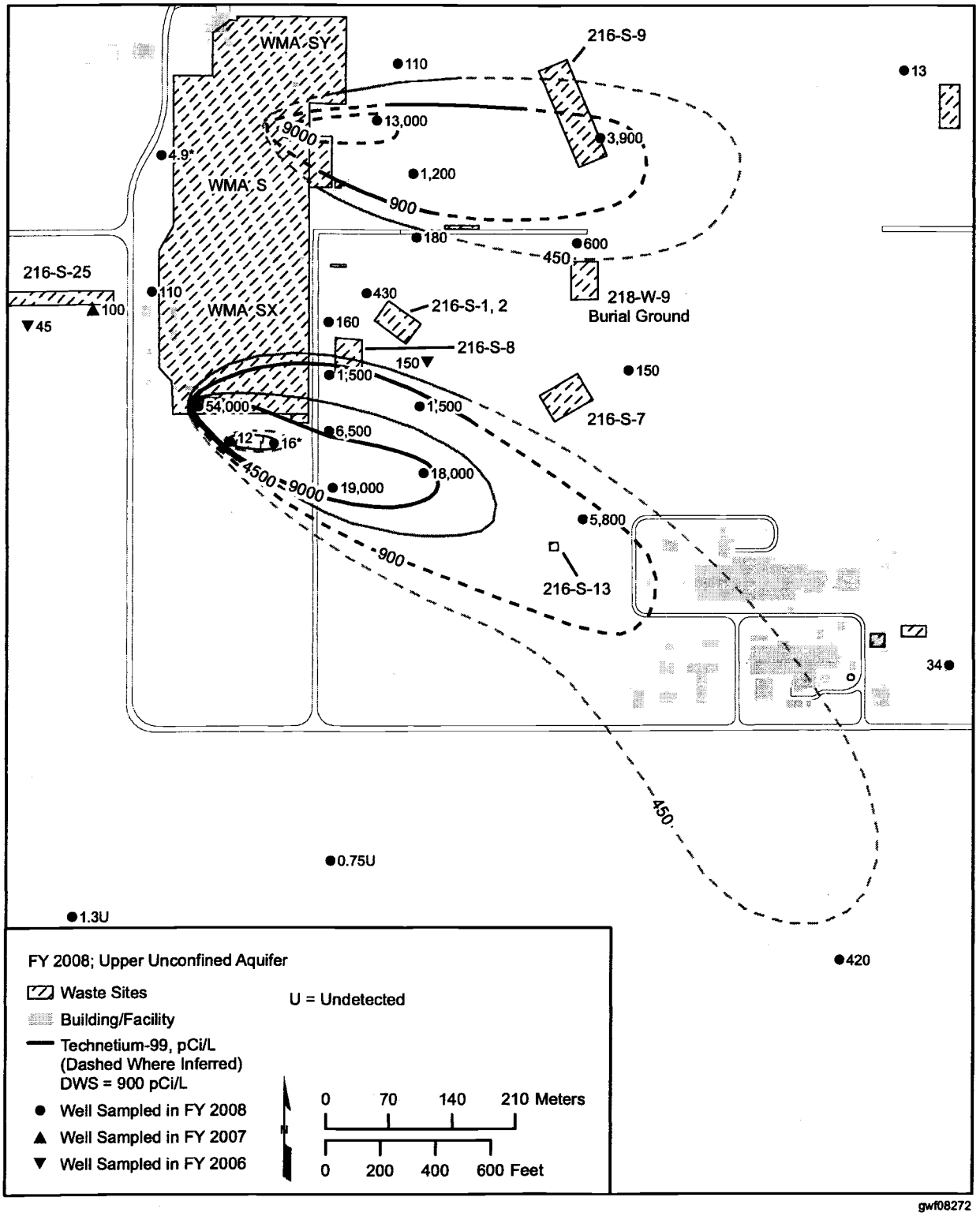
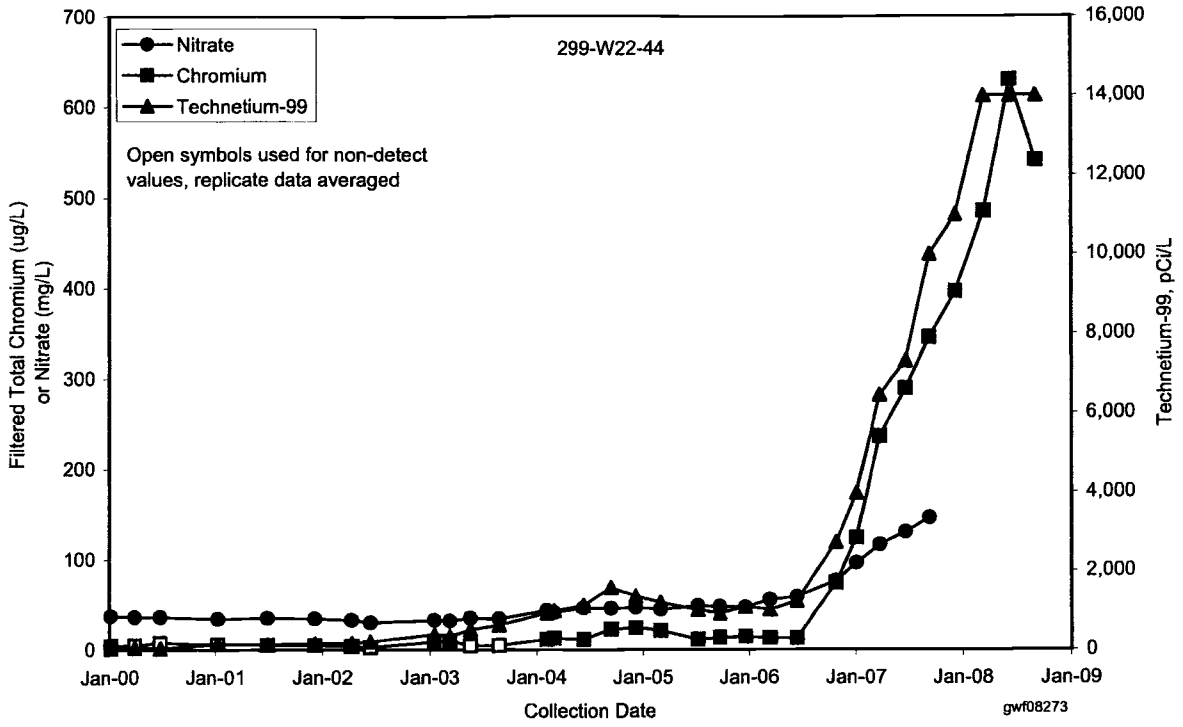


**Figure 2.9-20. Nitrate, Chromium, and Technetium-99 Concentrations Downgradient from S Tank Farm.**



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